MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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F. W. DYSON, Esq., M.A., LL.D., F.R.S., PRESIDENT, in the Chair.

His Highness the Maharaj Rana Bhawani Singh Bahadur of Jhalawar, K.C.S.I., Vice-President of the Astronomical Society of India, Jhalrapatan, Rajputana, India;
Thomas John I'Anson Bromwich, Sc.D., F.R.S., St. John's College, Cambridge;
William Shiach Cumming, H.M. Civil Service (Revenue Department), Craig Lynn, Rothes, Morayshire; and
Donald Maclean, Coats Observatory, Paisley,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Albert Henry Stewart Gillson, B.A., St. John's College, Cambridge (proposed by F. J. M. Stratton);
Daniel Hogarth, c/o Mr. C. G. M'Crea, 11 Macquarrie Place, Sydney, New South Wales, Australia (proposed by F. W. Levander);
Donald William Horner, F.R.Met.Soc., Milford, Ellington Avenue, Westgate-on-Sea (proposed by H. P. Hollis); and
William Petersen, 32 Inverness Terrace, Hyde Park, W. (proposed by Count de Miremont).

Eighty-four presents were announced as having been received since the last meeting, including, amongst others:—

Astrographic Chart: 29 charts from the Paris Observatory,

25 charts from the Algiers Observatory, 17 charts from Bordeaux Observatory, and 9 charts from Toulouse Observatory, presented by the French Minister of Public Instruction.

Observations of the Principal and other Series of Lines in the Spectrum of Hydrogen. By A. Fowler, F.R.S. (Plates 2–4.)

Introductory.

It is an interesting fact that for our knowledge of the spectrum of hydrogen we have been largely dependent upon observations of the heavenly bodies. The ultra-violet members of the Balmer series were photographed first by Sir William Huggins in the white stars, and afterwards more completely in the chromosphere during total eclipses of the Sun by Evershed, Dyson, and others. In 1896 another series of lines was discovered by E. C. Pickering in the spectrum of the star ζ Puppis, and was attributed to hydrogen in consequence of numerical relationships with the series ordinarily observed in laboratory experiments. The two series, as shown by Rydberg, are clearly related to each other in the same manner as the Sharp and Diffuse series in the spectra of other elements. From analogy with other spectra, Rydberg further calculated the positions of the lines in the Principal series, and gave their wave-lengths as 4687·88, 2734·55, etc. Only the first of these could be expected to be observed in any celestial body, for the reason that the others are beyond the limit for which our atmosphere is transparent. A very prominent line near 4688 had, in fact, been observed in stars of the fifth type (bright lines) and in some of the gaseous nebulæ, and this has also been assigned to hydrogen, in accordance with Rydberg's calculations.

The ζ Puppis lines appear in a few other stars, which are generally believed to be among the hottest in the heavens, but they have not hitherto been recorded in the spectrum of terrestrial hydrogen, even under the most promising conditions of experiment with powerful discharges. In his discussion of relative stellar temperatures, Sir Norman Lockyer has regarded these lines as representing "one among the last stages of chemical simplification so far within our ken," and has given the name "proto-hydrogen" to the form of hydrogen which produces them.* The modified gas has also sometimes been called "cosmic hydrogen."

In a report on the spectroscopic results which I obtained in India during the eclipse of January 22, 1898,† it was pointed out that there was a high-level chromospheric line about wave-length 4686 ‡ which was possibly identical with the first Principal line

* *Inorganic Evolution*, p. 60.

† *Phil. Trans.*, A, vol. cxcvii. p. 202 (1901).

‡ The chromospheric line in question does not appear in Young's catalogue, and was first recorded in photographs taken by the writer during the eclipse in Senegambia, April 16, 1893 (*Phil. Trans.*, A, clxxxvii. p. 618 (1896)).

of hydrogen, and that a line of unknown origin in about the same position was shown in a photograph of the spectrum of a helium tube which had been taken at the Solar Physics Observatory at South Kensington. Further details relating to this photograph were given by Lockyer and Baxandall in a subsequent paper,* where the wave-length of the terrestrial line was given as 4685·97 and that of the chromospheric line as 4685·90. They state: "The two calculated wave-lengths so nearly agree that it is very probable the line is of identical origin in the two cases. The eclipse line is, moreover, of the same nature as the helium eclipse lines, long and sharply defined. It would therefore seem that the line is due to a gas which is associated in some way with helium. The line, however, only appears in one photograph of the helium spectrum, and whether this is due to the particular sample of helium used, or to some special condition of current which is conducive to the appearance of the strange line, it is impossible to say." Apart from this, I am not aware of any successful attempt to reproduce even the brightest of the hypothetical hydrogen lines in laboratory experiments.

The present paper gives an account of the experimental observation not only of the Principal hydrogen series, but also of three members of the Sharp (ζ Puppis) series, and three members of an ultra-violet series which has not previously been suspected.

Method of Observation.

A careful watch had been kept for the line 4686 in occasional experiments on the helium spectrum extending over some years, but it was only recently that a faint line in that position was recognised in a tube of helium prepared from cleveite, in which hydrogen was the chief impurity. It was subsequently found possible to obtain the line very brightly by passing a strong condensed discharge from a 10-inch coil through such a mixture of hydrogen and helium in an ordinary Plücker tube. The gases obtained by heating cleveite *in vacuo* were admitted to the exhausted tube, after being subjected to the action of charcoal cooled with liquid air, a process which left the helium with a considerable proportion of hydrogen, together with traces of carbon compounds and mercury. The results of numerous experiments may be summarised very briefly. When the pressure of the gas was rather low (estimated at less than 0·5 mm.) the 4686 line was found only in the bulbs, near the junctions with the capillary tube, and did not extend far from the direct path of the discharge in a lateral direction; the intensity was slightly greater in the anode than in the cathode bulb. Under these low-pressure conditions, with the condensed discharge, the capillary tube showed very little of the helium spectrum, with little or no indication of 4686, while lines of silicon and oxygen were present on account of the decomposition of the glass. At higher pressures, estimated

* *Proc. Roy. Soc.*, vol. lxxiv. p. 546 (1905).

at about a millimetre, the line no longer appeared in the bulbs, but only in the capillary, and by sufficiently lengthening the air-gap it could easily be made the brightest line in the whole spectrum. The intensity of the line, in fact, increased with the length of the air-gap until the discharge ceased to pass, and the intensity of the ordinary lines of hydrogen correspondingly diminished.

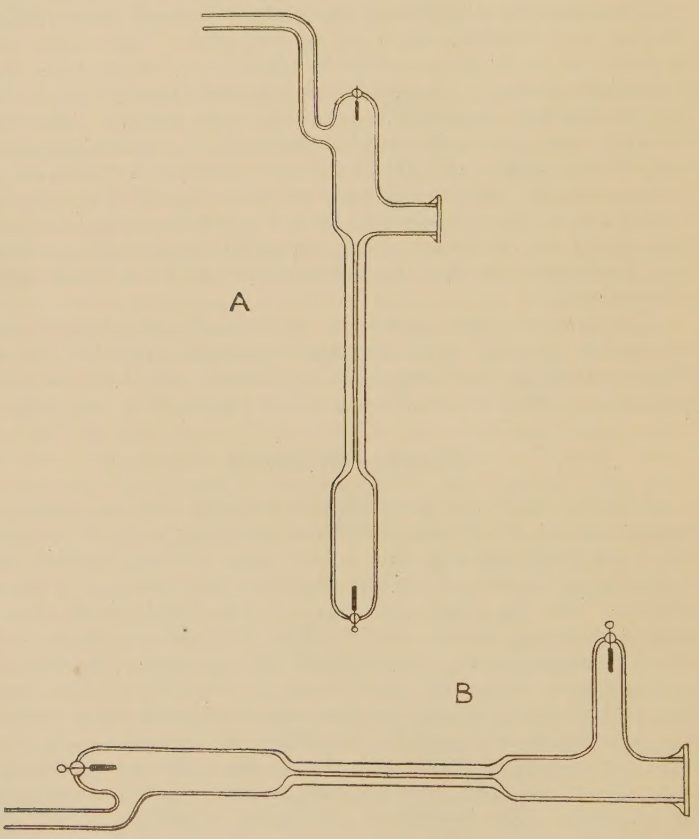

Fig. 1.

The identity of 4686 with the first Principal line of hydrogen was established by photographing other members of the series predicted by Rydberg. For this purpose, the vacuum tubes were provided with quartz windows, one having the window near the junction of the bulb and capillary for the low-pressure observations (fig. 1, *a*), and the other being arranged so as to give an end-on view of the capillary (fig. 1, *b*). Two additional members of the series were easily photographed, and in the low-pressure tube they were readily distinguished from the lines of helium, and from most

other lines, by their localisation. The lines were then quite sharply defined, but they were very broad and diffuse when obtained in the capillary at the higher pressures. It was at once observed that there was another very prominent line in the photographs near 3203, which varied exactly with the lines of the Principal series, and subsequently two other associated lines were traced.

The positions of these lines, as will appear later, can be calculated approximately from the Principal and Sharp series, and as they converge to the same limit as the former, they may be regarded as a second Principal series of hydrogen.

In the work at low pressures, a rather faint but quite distinct line was observed visually with a wave-length spectroscope and found to be about 5411, near the position assigned by Rydberg to the first observable member of the Sharp series. There was no room for doubt when similar lines about 4541 and 4200, corresponding to the second and third members of the series, were subsequently photographed. All three were localised in the same manner as the lines of the Principal series. The Sharp series, however, was only very feebly developed, and no further members could be traced with certainty. In the experiments at the higher pressures, in the capillary, they were not observed.

In many of the photographs the newly observed lines occur in company with lines of carbon, oxygen, mercury, silicon, and aluminium,* but there is no difficulty in identifying them by their special behaviour; the systematic broadening (amounting almost to disappearance, through diffuseness, in the case of the more refrangible lines) is a striking feature at the higher pressures. Attempts to reduce the impurity lines by immersing the discharge tube in liquid air, and in other ways, were only partially successful.

So far it has not been found possible to obtain the lines in question from hydrogen alone under apparently identical conditions, though there is not the slightest difficulty in obtaining them when helium is also present. It is remarkable also that a very small proportion of hydrogen is sufficient to show 4686 brightly; this was found to be the case in a commercial helium tube where the ordinary hydrogen lines could only be detected during the passage of the strong discharge. One hesitates to believe, however, that the presence of helium is an indispensable condition for the production of the Principal series of hydrogen, and further experiments on this point will be made. In the absence of strict experimental proof that 4686 and the associated lines are really due to hydrogen, Rydberg's theoretical investigations may be regarded as justifying such a conclusion. It can at least be said that the lines have only been produced when hydrogen was known to be present.

In view of the foregoing observations, it seems likely that the passage of a strong discharge, and observations for 4686, will provide the most sensitive test for traces of hydrogen in samples of helium.

All the determinations of wave-lengths have been made from

* The aluminium lines were derived from the electrodes.

photographs taken under the low-pressure conditions, which give the lines with perfect sharpness. The instruments employed were a small quartz spectrograph giving the range 2200 to 7000 in a space of 5·5 cm., and a larger instrument of similar construction giving the same range in 16 cm. The line 4686 was also photographed with a concave grating of 10 feet radius.

The First Principal Series.

The position of the first line of the Principal series was determined from a photograph taken with two hours' exposure in the first order of the concave grating, the comparison spectrum being that of the iron arc. The line was obtained from the bulb of the discharge tube and was as sharply defined as the lines of helium. Using the international standards, the deduced wave-length was 4685·81, which is equivalent to 4685·98 on the scale of Rowland. The positions of the remaining lines were determined from photographs taken with the quartz spectrographs, giving dispersions in the respective regions which are specified in Table I. The intensities are on a scale of 10 for the strongest line.

TABLE I.

Principal Series of Hydrogen Lines.

Intensity.	λ Rowland.	Limit of Error.	Oscillation Frequency *in vacuo*.	Limit of Error.	Rydberg's Calculated Wave-Lengths.	Remarks.
10	4685·98	0·01	21334·4	0·1	4687·88	Dispersion 5·5 tenth metres per mm.
7	2733·34	0 05	36574·7	0·7	2734·55	,, 12·5 ,, ,,
5	2385·47	0·05	41907·9	0·9	2386·50	,, 8 ,, ,,
2	2252·88*	0·10	44374·2	2·0	2253·74	,, 18·5 ,, ,,
...	[2186·69]	...	[45717·1]	...	2187·60	Calculated by formula.

It will be seen that all the lines are slightly more refrangible than the positions calculated by Rydberg, but the divergence is not greater than might have been expected in view of the approximate formulæ which he employed.

Using the first two lines for the calculation of constants, we get the formula,

$$n = 48764{\cdot}0 - \frac{109675}{(m + 0{\cdot}999606)^2},$$

where 109675 is the general series constant, n is the oscillation frequency *in vacuo*, and m takes the values 1, 2, 3, etc.; 48764 is the convergence frequency, or limit, of the series, being the value of n when m becomes infinite.

The observed *minus* computed values on the frequency scale are respectively 0·0, 0·0, −0·1, −2·1.

* This is apparently coincident with a faint line of mercury.

The observed position of the first Principal line 4685·98 completely justifies its identification in certain celestial spectra. In the Sun's chromosphere, as already pointed out, it occurs as a high-level line, for which Lockyer gives the wave-length 4685·90, Dyson 4685·86, and Evershed 4685·7. Like the helium lines, it is probably not ordinarily represented by a dark line in the solar spectrum, Rowland's nearest line being a very faint one at 4686·028.

For the corresponding line in the Wolf-Rayet stars, the wave-length given by Campbell is 4688, but the line is broad in this case and closer agreement can scarcely be expected. In some of the Orion stars, it appears as a dark line for which Pickering gives the wave-length 4685·4.

In nebulæ, according to Wright, the wave-length is 4685·73 ± 0·10.*

According to Max Wolf, the line 4686 occurs also in the spectrum of the ring nebula in Lyra,† but only in the central "dark" space, and is thus clearly differentiated from the other nebular lines. With the exception of another line at 3729, it is the only "unknown" line not accounted for by Dr. Nicholson in his theoretical discussion of the spectra of nebulæ.‡

The Second Principal Series.

The new series of lines in the ultra-violet, as already mentioned, is attributed to hydrogen, because the positions of the lines can be approximately calculated from the constants of the other series. They are always found in company with the lines of the Principal series, and are nearly of the same order of brightness. Particulars of the observed lines are given in Table II.

TABLE II.

The Second Principal Series of Hydrogen Lines.

Intensity.	λ Rowland.	Limit of Error.	Oscillation Frequency *in vacuo*.	Limit of Error.	Remarks.
8	3203·30	0·05	31208·9	0·5	Dispersion 20 t.m. per mm.
5	2511·31	0·05	39808·2	0·8	,, 9 ,,
2	2306·20	0·10	43348·4	1·9	,, 21 ,,
...	[2214·72]	...	[45137·5]	...	Calculated by formula.

Calculating from the first two lines, we get the formula,

$$n = 48763{\cdot}8 - \frac{109675}{(m + 0{\cdot}499506)^2},$$

giving errors of 0·0, 0·0, and + 1·8 on the frequency scale.

The new series has thus the same limit as the first Principal series, and the variable part of its equation is nearly identical with that of the Sharp series. Hydrogen is apparently unique in having

* *L.O.B.*, vol. i. p. 156 (1902).
† *Sitz. der Heidel. Akad.*, 1911, Abhand. 27.
‡ *Monthly Notices*, vol. lxxii. p. 177 (1912).

two Principal series related to each other in the same manner as the Diffuse and Sharp series.

The available records of celestial spectra do not extend far enough into the ultra-violet to exhibit the line 3203, but it is possibly just within range of photographic observation with quartz spectrographs, and should be found in such planetary nebulæ as N.G.C. 7027, which show the principal hydrogen line at 4686.

The Sharp Series.

It has so far only been possible to identify three members of the Sharp series with reasonable certainty in the terrestrial spectrum. They have only been photographed with small dispersion, and their wave-lengths cannot therefore be accurately determined. Further efforts will be made to improve on these results, as a precise knowledge of the wave-lengths would be of great value in the discussion of the relationships of the different series of lines to each other. Particulars of the lines, together with the positions observed in stars by Pickering, and computed by Rydberg, are given in Table III.

TABLE III.

Sharp Series of Hydrogen Lines.

Intensity.	λ Rowland.	Limit of Error.	Oscillation Frequency *in vacuo*.	Limit of Error.	Pickering's Observed λ.	Rydberg's Calculated λ.	Remarks.
1	5410·5	1·0	18477·6	3·4	5413·6	5412·8	Dispn. 93 t.m. per mm.
1	4541·3	0·25	22014·0	1·2	4542·4	4543·3	Dispn. 58 t.m. per mm.
<1	4200·3	0·5	23801·1	2·8	4200·7	4201·5	Dispn. 130 t.m. per mm.
...	...	...	...	...	4026·0	4027·3	...
...	...	...	...	...	3924·0	3925·2	...
...	...	...	...	...	3860 8	3859·8	...
...	...	...	...	...	3815·7	3815·2	...
...	...	...	...	...	3783·4	3783·4	...

For want of more accurate wave-lengths the formula for this series cannot well be determined from the observations, but it may be deduced approximately from the Principal series, by reversing Rydberg's procedure. The difference between the first Principal line and the limit of the series to which it belongs gives the limit of the Sharp series, and the adopted value of μ is that which makes $109675/(1+\mu)^2$ equal to the limit of the Principal series. The resulting equation for the Sharp series is

$$n = 27429{\cdot}6 - \frac{109675}{(m+0{\cdot}4997)^2}.$$

The observed *minus* computed values for the frequencies of

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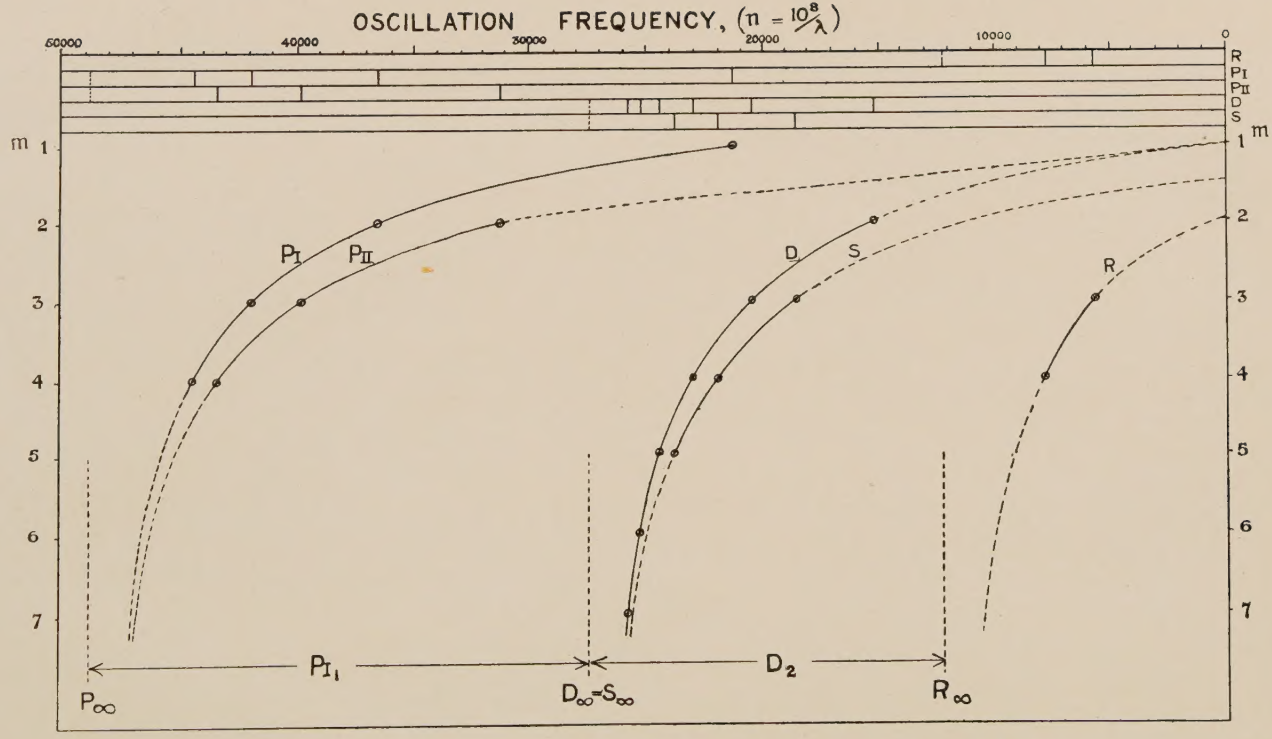


CURVES SHOWING DISTRIBUTION OF KNOWN HYDROGEN LINES IN FIVE RELATED SERIES.

the three observed lines are $+2{\cdot}6$, $-0{\cdot}1$, and $-2{\cdot}5$, which are within the limits of error. The equation can only be regarded as provisional, especially as the limit of the series is $10{\cdot}8$ greater than the generally accepted limit of the Diffuse series.

Relations between the Different Series.

The general investigation of series lines in spectra has indicated some well-known relations between the different series of lines in the spectrum of the same element, and it may be interesting to see how far they are verified by the new data in the case of hydrogen. For the sake of completeness, reference should be made to an infra-red hydrogen series predicted by Ritz,* two members of which were observed by Paschen at *wave-lengths* $18751{\cdot}3 \pm 1$ and $12817{\cdot}6 \pm 1{\cdot}5$, Ritz's computed positions being $18751{\cdot}6$ and $12818{\cdot}7$.

The more general relations between the five known series of hydrogen lines are shown graphically in Plate 2, where the continuous parts of the curves represent actual observations in the terrestrial spectrum. In the diagram, P. ∞ denotes the convergence frequency, or limit, of the Principal series; P. I. (1) indicates the frequency of the first line of the first Principal series, and so on.

The connection between the different series is also well exhibited by writing the equations for them in the manner adopted by Rydberg and Ritz. In an approximate form, they are as follows, where n denotes the oscillation-frequencies of the lines *in vacuo*, and C is the general series constant, 109,675, derived from the Balmer (Diffuse) series:—

First Principal series .	$n = C\left\{\frac{1}{1{\cdot}5^2} - \frac{1}{(m+1)^2}\right\}$	$m = 1, 2, 3, \ldots$
Second Principal series	$n = C\left\{\frac{1}{1{\cdot}5^2} - \frac{1}{(m+0{\cdot}5)^2}\right\}$	$m = 2, 3, 4, \ldots$
Diffuse series . .	$n = C\left\{\frac{1}{2^2} - \frac{1}{(m+1)^2}\right\}$	$m = 2, 3, 4, \ldots$
Sharp series . .	$n = C\left\{\frac{1}{2^2} - \frac{1}{(m+0{\cdot}5)^2}\right\}$	$m = 2, 3, 4, \ldots$
Ritz's series (infra-red)	$n = C\left\{\frac{1}{3^2} - \frac{1}{(m+1)^2}\right\}$	$m = 3, 4, 5, \ldots$

The equation for the Diffuse series represents the observed lines to $m = 30$ practically within the limits of error, but the remaining equations are less exact.

From the diagram and formulæ it will be seen that the two Principal series converge to the same limit. The above formulæ give this as $48744{\cdot}4$, while the values derived from the observations are $48764{\cdot}0$ and $48763{\cdot}8$.

* *Œuvres de Walther Ritz*, p. 522 (Paris, 1911).

A similar result is to be expected for the Diffuse and Sharp series, but this cannot yet be rigorously tested. The limit from the above formulæ is 27418·8, and this appears to be in agreement with the lines of the Diffuse series.

According to the Rydberg-Schuster law, the difference between the limit of the Principal series and the common limit of the Diffuse and Sharp series should be equal to the frequency of the first line of the Principal series. This is evidently very nearly true in the case of hydrogen, but it would require 27429·6 in place of 27418·8 for the limit of the Diffuse series to give the first Principal line correctly. With the adopted form of equation, this value does not exactly satisfy the Diffuse series, and either the law is not strictly true or the method of determining the limits of the series is not sufficiently precise to verify it.

In view of the occurrence of the foregoing series in pairs, a sixth (infra-red) series, in association with that of Ritz, might reasonably be expected, having the limit at $C/3^2$, and $(m+0{\cdot}5)$ in place of $(m+1)$.

It will be observed that the first Principal, Diffuse, and Ritz series would be parallel to each other if the approximate equations were exact. The first two would be separated by an interval equal to the frequency of the first Principal line, but the following data of observation, as well as the more accurate equations previously given, show that this is not strictly true :—

P.I. series	21334·4	36574·7	41907·9	44374·2	48764·0 (limit)
D. ,,	0·0	15232·3(Hα)	20563·7(Hβ)	23031·1(Hγ)	27418·8 ,,
Diff.	21334·4	21342·4	21344·2	21343·1	21345·2

The separation of the Ritz from the Diffuse series is, in like manner, nearly equal to the frequency of the first line of the Diffuse series (Hα).

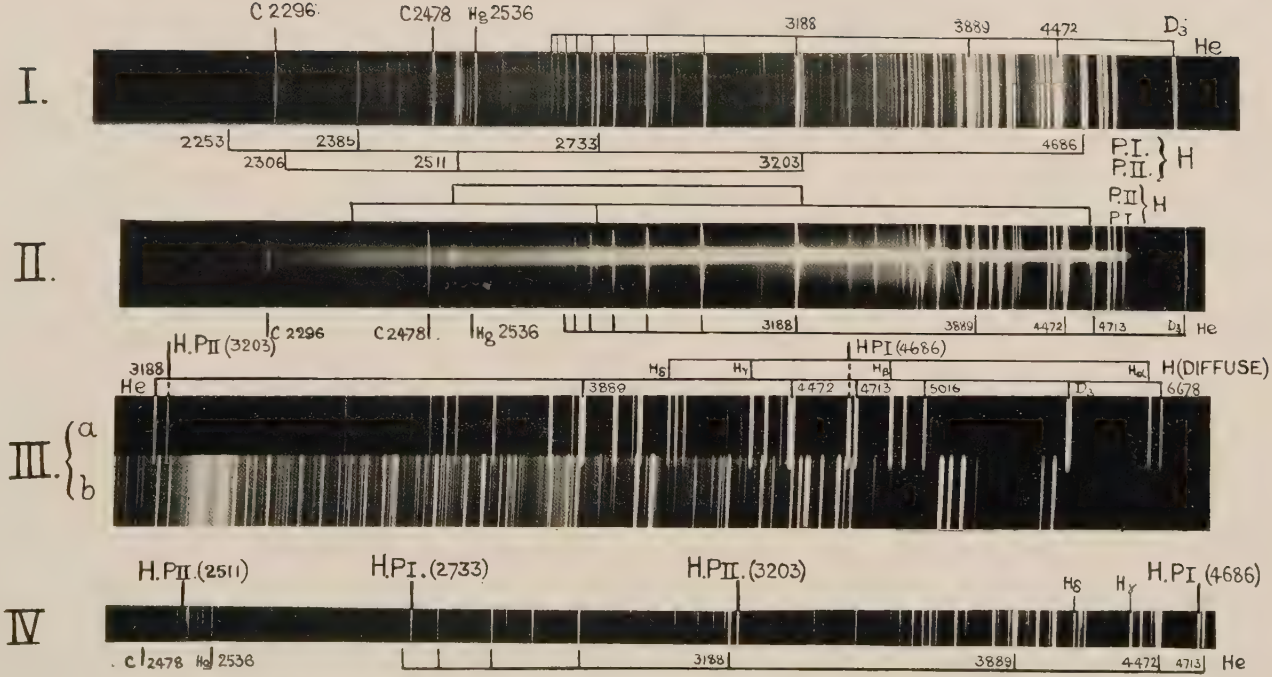
The second Principal series is also parallel, or nearly so, to the Sharp series, the two being separated by the frequency of the first Principal line as before. This is shown by the following data :—

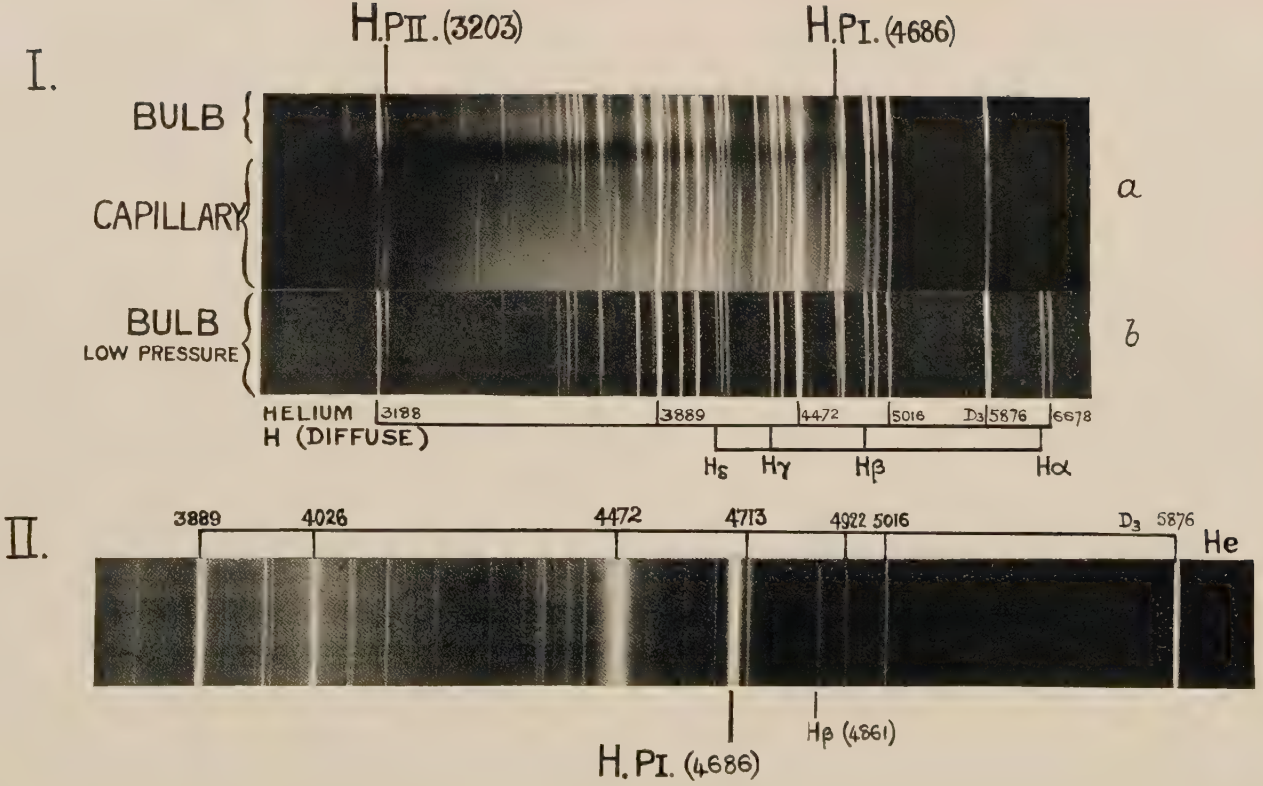
P.II. series	39808·2	43348·4	45137·5	48763·8 (limit)
S. ,,	18477·6	22014·0	23801·1	27429·6? ,,
Diff.	21330·6	21334·4	21336·4	21334·2

Summary.

(1) The Principal and Sharp series of hydrogen lines have been observed by passing a strong condensed discharge through a mixture of hydrogen and helium. Four members of the Principal and three of the Sharp (ζ Puppis) series have been identified.

(2) The lines of the Principal series are slightly more


I.
C 2296
C2478
Hg 2536
3188
3889
4472
D3
He
2253
2385
2733
4686
2306
2511
3203
P.I.
P.II.
H
II.
P.II
P.I
H
C 2296
C2478
Hg 2536
3188
3889
4472
4713
D3
He
III.
a
b
H.PII (3203)
H PI (4686)
3188
He
Hδ
Hγ
Hβ
Hα
H(DIFFUSE)
3889
4472
4713
5016
D3
6678
IV
H.PII.(2511)
H.PI.(2733)
H.PII.(3203)
Hδ
Hγ
H.PI (4686)
C 2478
Hg 2536
3188
3889
4472
4713
He


I.
H.PII. (3203)
H.PI. (4686)
BULB
CAPILLARY
BULB
LOW PRESSURE
a
b
HELIUM
H (DIFFUSE)
3188
3889
4472
5016
D3 5876
6678
Hδ
Hγ
Hβ
Hα
II.
3889
4026
4472
4713
4922
5016
D3 5876
He
Hβ (4861)
H. PI. (4686)

refrangible than the positions calculated by Rydberg. The wave-length of the first line is 4685·98 on Rowland's scale, which is in satisfactory agreement with the corresponding line observed in nebulæ, the chromosphere, and bright-line stars.

(3) A second Principal series of hydrogen lines has been discovered. The first line is at wave-length 3203·30, and the lines converge to the same limit as the first Principal series.

(4) The production of the new lines gives a further indication of the probability that there are no special kinds of matter in celestial bodies, and that most, if not all, of the celestial spectra are well within range of laboratory experiments.

The author has pleasure in acknowledging the valuable assistance which has been rendered by Messrs. W. E. Curtis, B.Sc., and W. Jevons, B.Sc., in carrying out some of the experiments, and in preparing the illustrations.

Description of Plates.

All the photographs represent the spectrum of hydrogen and helium, together with a few impurities. An ordinary Plücker tube was employed, and the discharge was that from a 10-inch coil, with condenser and large air-gap. The lines of the ζ Puppis (Sharp) series are in all cases too faint to appear in the reproductions.

Plate 2.—Curves showing the distribution of known hydrogen lines in five related series.

Plate 3, No. I*a*.—Spectrum near junction of bulb and capillary, with gas about 1 mm. pressure. Helium lines are strong in the bulb and weak in the capillary. The lines 4686 and 3203 are broad and strong in the capillary, but weak in the bulb. Other lines in the lower part of the spectrum are due to oxygen and silicon.

No. I*b*.—Bulb at low pressure, showing localisation of 4686 and 3203. Smaller quartz spectrograph.

No. II.—Capillary tube, at about 1 mm. pressure, showing 4686 with great intensity. Larger quartz spectrograph. All spectra on this plate were photographed through glass vacuum tubes.

Plate 4, No. I.—Spectrum of bulb, with smaller quartz spectrograph, giving a general view of spectrum and showing the chief new hydrogen lines. The line 2511 is intensified by adjacent lines of carbon. Some of the lines are due to silicon.

No. II.—Capillary tube, end-on, showing simultaneous broadening of the lines of the two principal hydrogen series. The longer lines are from the bulb. There are two faint carbon lines overlying the broad line 2511 of HP II. Smaller quartz spectrograph.

No. III*a*.—Spectrum of bulb, with larger quartz spectrograph, showing 4686 and 3203. (*b*) Comparison spectrum of copper.

No. IV.—Spectrum of bulb showing some of the new lines. Many of the short lines in the upper part of the spectrum are due to silicon. The line 2511 is here not affected by carbon lines. Larger quartz spectrograph.

Preliminary Note on the later Spectrum of Nova Geminorum No. 2. By F. J. M. Stratton, M.A., Assistant in Astrophysics in the University of Cambridge.

(*Communicated by Prof. H. F. Newall, F.R.S.*)

On the return of the Nova this autumn it was out of reach of the two-prism spectroscope with which the series of plates were obtained in the spring. Since that time a new spectroscope of suitable dispersion has been constructed, and photographs of the spectrum have been secured on December 6 and December 12. The hydrogen bands Hβ, Hγ, Hδ are still present on the plate, which extends from λ 4100–λ 5020, but the most prominent features are the nebular bands λ 4364 and λ 5007.

The hydrogen bands have the same width (about 25 t.m.) as in the spring, and Hγ shows a maximum displaced towards the red in approximately the same position as in the earliest plates: the position of the maximum on March 20 being λ 4347·1–λ 4352·2, and on December 6, λ 4347·9–λ 4353·8. The nebular band at λ 4364 shows a maximum λ 4368·0–λ 4375·8 displaced to the red by the same amount relatively as the late and early hydrogen bands. This consistency of structure for different elements and different epochs was a feature of the spectrum of Nova Persei, No. 2.

Other nebular bands present in the spectrum are $\mu\mu$ 496, 464, 468, 471, the order of brightness of the bands on the plate being $\mu\mu$ 436, 501, 464, Hβ, Hγ, 496, Hδ, 468, 471.

There are indications on the plate of three very faint bands at $\mu\mu$ 458–461, 473–477, 480–484. But these bands are very difficult to measure on the plate, and require confirmation. This region, or at any rate the region λ 4750–λ 4850, is generally blank in the later stages of Novæ, and brightness here would seem to be a new feature in the present star. The magnitude seems to be still fluctuating, and any corresponding changes in the spectrum will be well worth following closely.

The Distribution in Latitude of the Absorption Markings in Hα Spectroheliograms. By T. Royds, D.Sc.

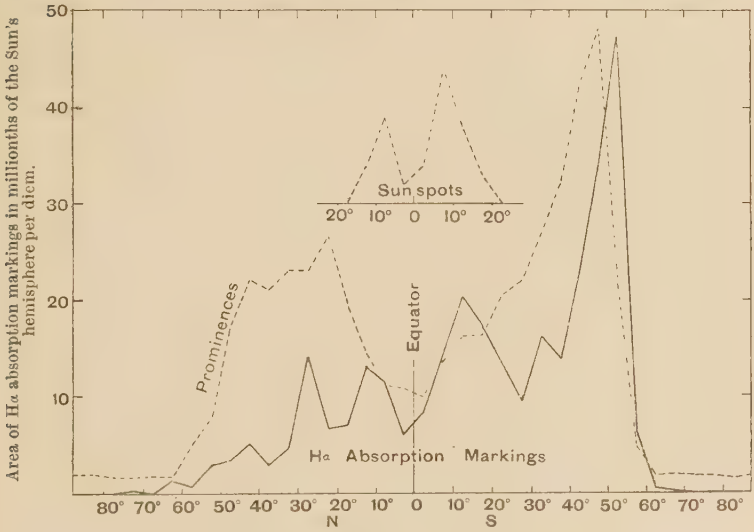
(*Communicated by John Evershed.*)

The curve accompanying this paper gives the distribution in latitude of all the absorption markings seen in the Hα spectroheliograms obtained at this observatory since the photographic records were begun in April 1911 up to the end of June 1912.* The series is not a very complete one, since photographs cannot be taken except with a fairly bright sun on account of the long exposure required. Hα spectroheliograms have been obtained on 250 out of 427 days on which the instrument was in working order. On 62 plates no absorption markings were visible.

* The curves for 1911 and the first half of 1912 will be given separately in the *Kodaikánal Observatory Bulletin*, No. xxix.

The positions of the markings were obtained by projecting images of the negatives on to 8-inch charts on which were marked the lines of heliographic latitude and longitude at 5° intervals. The absorption markings were then drawn in by hand and their positions read off from the charts. The error in latitude may be one or two degrees. The areas of the drawings were measured and totalled for each zone of 5°.

The areas given are uncorrected for foreshortening; they are expressed in millionths of the Sun's hemisphere and divided by the total number of days on which spectroheliograms were obtained. If the areas are corrected for foreshortening as though the markings are simply a surface phenomenon, the curve obtained shows the



Heliographic Latitudes—April 1911 to June 1912.

same features, generally speaking, but the ratio of the ordinates increases with the distance from the equator.

The areas of the Hα absorption markings in each zone are shown by the continuous line in the diagram. The dotted line shows on a convenient scale the profile areas of the prominences at the solar limb for the same period. The upper curve denotes the number of sunspots in each zone.

Of the total areas of absorption markings 74·1 per cent. occur in the southern hemisphere,* whilst of prominences 57·3 per cent.

* Since the presence of markings in the photographs depends on the position of the secondary slit on the Hα line, it is important to consider the effect of a tilt of the slit. The setting is observed at one extremity of the slit, and if the secondary slit is not accurately parallel to the solar line there will be, as a rule, more absorption markings seen near this end of the slit, and fewer at the other. The result would be a systematic excess in the south-east quadrant of the Sun.

are south of the equator. There is a slight preponderance on the west of the central meridian over the east.*

In addition to the marked excess in the southern hemisphere there are the following noteworthy features:—

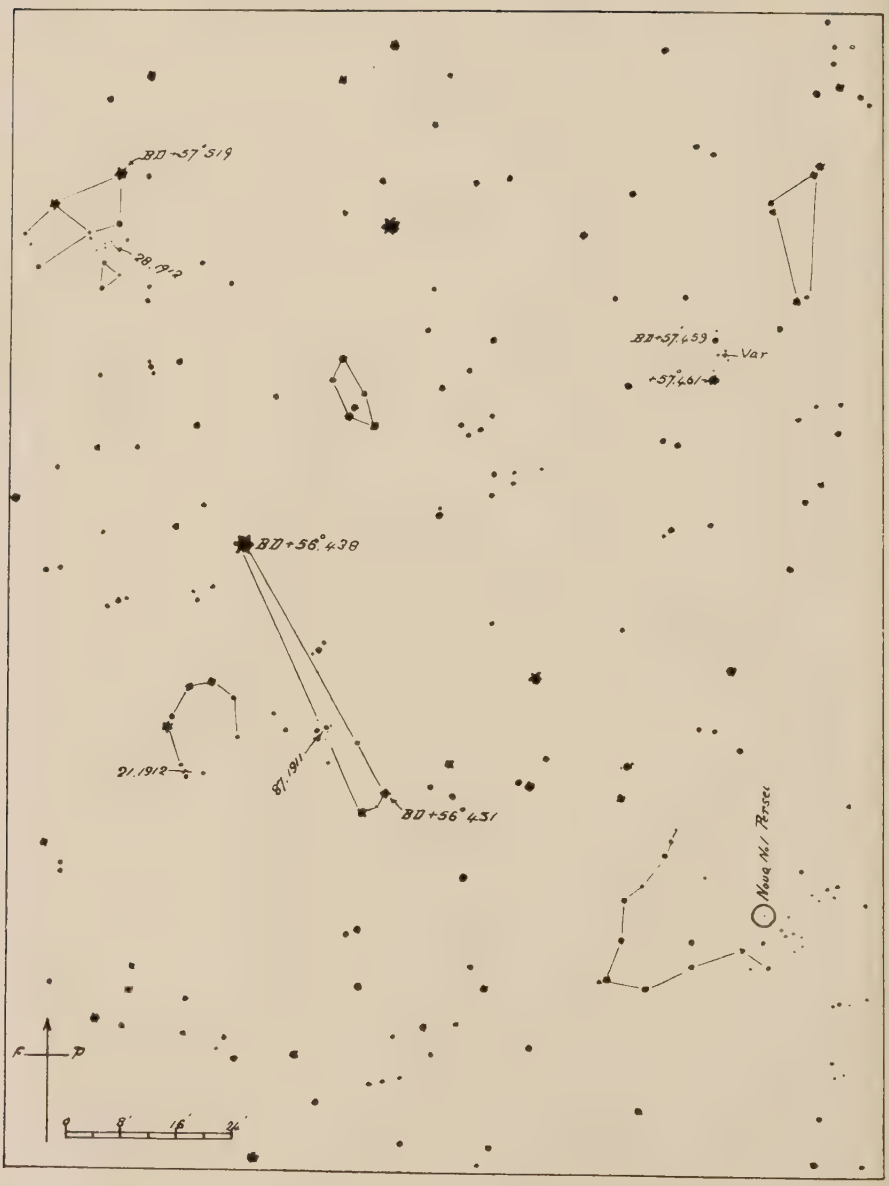
1. *A conspicuous maximum in the zone* 50° *to* 55° *S.*—This is also a striking feature of the prominence curve where the highest point is in the zone 45° to 50° S. At the corresponding north latitude this maximum is much smaller in the prominence curve, and almost absent from the Hα markings, the highest point in both cases being somewhat nearer the equator, namely, between 40° and 45° N. The Hα maximum between 40° and 45° N. is more prominent in the first half of 1912 than in 1911 (April to December).

2. *Maxima in the zones* 5° *to* 10° *N.*, 10° *to* 15° *S., and a minimum near the equator.*—Hα markings frequently attend on sunspots, and this is clearly shown by the close correspondence of the two curves between 20° north and south of the equator. During the first half of 1912 no sunspots were observed north of the equator, and Hα markings were less frequent between 0° and 20° N., a maximum being still evident though less prominent.

3. *A maximum in the zone* 25° *to* 30° *N.* is a striking feature of the curve of Hα markings; a maximum also occurs in the prominence curve in the zone 20° to 25° N. At the corresponding south latitude a minimum occurs, but the absolute ordinate is 65 per cent. of that in the north. It is noteworthy that the above-mentioned maximum is entirely due to markings seen in 1911, and that the prominence maximum also is only present in 1911. In the period 1912 January to June the Hα activity in this latitude is insignificant; on the other hand, the activity in the corresponding south latitude is marked, a maximum occurring in the zone 30° to 35° S., in the curve for that half year taken alone. These facts point to the probability that the activity in these latitudes fluctuates considerably. The series of photographs is not sufficiently complete, however, to obtain reliable curves of the monthly activity which would give more conclusive evidence. No sunspots or flocculi have been seen in these latitudes during the period studied. It may be that this activity, so clearly evidenced by the Hα absorption markings, is a forerunner of the appearance of spots and flocculi in these latitudes, denoting the commencement of another sunspot cycle.

Kodaikánal Observatory:
1912 *November* 12.

* For many years there has been a slight excess of east over west in the case of prominences. See Evershed, *Kodaikánal Observatory Bulletin*, No. xxviii.



GENERAL INDEX DIAGRAM.

REGION OF THE CLUSTERS IN PERSEUS.—C. R. D'ESTERRE.

A Note on Some Observations of the Region around the Star Clusters H. VI. 33, 34 *Persei.* By C. R. D'Esterre. (Plate 5.)

In the course of experiments in astronomical photography during the years 1909–12, with a view to obtaining useful results from a 15-inch reflector and three portrait-lens cameras attached thereto, many difficulties were encountered owing to the unsatisfactory details of an equipment intended primarily for casual observations only, and also from a lack of knowledge as to the exact requirements of the work.

This led to a concentration of attention night after night on a very few regions, partly in order to save loss of time in finding new guiding stars, and partly that the plates might be more readily comparable, defects gradually eliminated, and a higher degree of perfection attained. As the results of this experimental work began to approach a satisfactory standard, they suggested the idea of seeking an answer to the question "What happens from night to night amongst the minute stars which make up the general background of the Milky Way?" and led to the selection, amongst others, of the region round the well-known clusters H. VI. 33, 34 Persei as one embodying many features common to the whole formation, and capable of being watched in these latitudes practically throughout the entire year.

The first plate of the series which was considered worthy of preservation was obtained on August 5, 1911, and since then 127 exposures have been made on 79 nights, as follows:—

Thirty plates between August 30, 1911, and December 6, 1912, with a $2\frac{3}{4}$-inch Dallmeyer portrait lens of 8-inch focus, covering the region 1 hr. 20 mins. to 2 hrs. 50 mins. and 50° N. to 63° N.; average exposure time 35 mins., showing stars to $13^{m}{\cdot}0$ within the region free from objectionable spherical aberration; plates marked "D," and used only as a court of appeal from the exposures obtained simultaneously with the larger cameras.

Seventeen plates between September 12 and December 6, 1912, with a $3\frac{1}{2}$-inch Dallmeyer camera of $12\frac{1}{2}$-inch focus, covering the region 1 hr. 0 min. to 3 hrs. 0 min. and 50° N. to 62° N.; average exposure 50 minutes, showing stars to $14^{m}{\cdot}0$ over the best regions; plates marked "Da" and used to check those of larger cameras and also compared *inter se* by superposition.

Forty-one plates between August 5, 1911, and December 6, 1912, with a $6\frac{1}{2}$-inch Voigtländer portrait lens of 30-inch focus, covering the region 1 hr. 40 mins. to 2 hrs. 40 mins. and 53° 30′ N. to 59° N.; average exposure 36 minutes, showing stars to $14^{m}{\cdot}0$. These plates are marked "V"; they are the primary source of information, and are always carefully compared by superposition.

Thirty-nine plates between December 14, 1911, and October 15, 1912, with the 15-inch reflector, 74·5-inch focus. These are taken for the study of special portions of the region covered by the portrait lenses; average exposure 70 minutes, showing stars

to $15^{m}\cdot5$; plates marked "R," and always compared by superposition.

In order to obtain an approximate idea of the number of stars dealt with, sample plates of the V, Da, and R series have been selected and laid on a photographic measuring scale on which 4400 squares covered all but the extreme edges of the V and Da plates, and 1700 squares covered an R plate.

On each plate two sets of ten squares were taken impartially over the whole area and the number of stars per square counted down to the average minimum magnitude comparable by superposition on plates not too much darkened by diffused skylight, viz. $11^{m}\cdot0$ Da, and $12^{m}\cdot5$ V. The counts were found to agree remarkably well, there being in no case a difference greater than 0·5 star per square in the means in each series; the results were as follows:—

For a normal Da plate, 9 stars per square over 4400 squares, covering approximately 180 square degrees, equal to 39,600 stars per plate and 220 stars per square degree.

For a normal V plate, 4 stars per square over 4400 squares, covering approximately 40 square degrees, equal to 17,600 stars per plate and 440 stars per square degree.

The results for the R plates will be referred to later.

The analysis of the above-mentioned material has resulted in the discovery of one Nova, two undoubted variable stars, and one star in which the fluctuation of brightness is strongly suspected, viz. the Nova 87, 1911; see general diagram and also detail diagram.

The object is situated preceding and slightly south of the 9·5 mag. star B.D. $+56^{\circ}436$, marked *a* in detail diagram.

From the mean of a large number of measures on plates R 37 and V 170 its position has been found from neighbouring B.D. star to be 2 hrs. 0 min. 13·4 secs. $\pm0\cdot4$ sec. Dec. N. $56^{\circ}30' \pm 0''\cdot1$ (1855·0), or 2 hrs. 3 mins. 16·6 secs. N. $56^{\circ}43''\cdot2$ (1900·0). It was discovered on plate V 116, taken November 13, 1911, $10^{h}\cdot1$., exp. 30 mins.; and the checking plate D 92, taken simultaneously, shows it quite distinctly, notwithstanding the minute scale of $1^{mm} = 1000''$.

Five plates taken between August 5 and October 18, 1911, showing stars down to $14^{m}\cdot0$, have no trace of any object in its position.

The visual magnitude of *a* is given in the *Durchmusterung* as $9^{m}\cdot5$, and its photographic magnitude appears to me to be the same; taking this as a basis, the magnitude of the Nova on November 13 is estimated as $10^{m}\cdot5$. Unfavourable weather conditions prevented its reobservation until November 21, $8^{h}\cdot5$, when two plates, V 119, and D 95, exp. 30 mins., again show it quite clearly but fallen to $11^{m}\cdot5$.

On December 11, $6^{h}\cdot8$, plates V 134 and D 110 show stars down to $14^{m}\cdot0$ and $12^{m}\cdot8$ respectively, but no trace of the object can be found. The region was therefore taken up with the

reflector, but the extremely unfavourable conditions prevailing throughout the entire winter 1911–1912 made the investigation a very difficult one.

Three plates between December 14 and 22 showed faint traces of an object in the position covered by the image of the object on the V and D plates, but are really only serviceable as showing that between these dates its magnitude was not greater than $14^{m}\cdot5$. A better exposure on January 9, 1912, brought out the very interesting fact that its position was occupied by a double star, distance

Diagram showing the stars in the immediate neighbourhood of 87, 1911 Persei.

7″, position angle 200° ±, magnitude of components N. $15^{m}\cdot2$, S. $15^{m}\cdot5$. This appeared so remarkable that every effort was made to thoroughly investigate the object. Fifteen plates, some with exposures of two and three hours, obtained between January 27 and April 17, 1912, all showed a double object, and some suggested strongly that it was nebulous and that there was faint nebulosity in the neighbourhood, but no entirely satisfactory plate was obtained before the region became too low in the north-west.

In the *Astronomische Nachrichten*, No. 4555, Herren Miethe and Seegert announced the fact that between January 12 and 16, 1912, with the 30-cm. refractor at Charlottenburg, they had photographed

wisps of nebulosity about the position of the object; and in *A.N.* 4585 Herr Max Wolf, with the 29-inch reflector of the Königsthul Observatory, exp. 58 mins., shows clearly that the object is a double star, and mentions the important fact that an exposure of 5 hours on October 10, 1904, with the 16-inch Bruce telescope, proves the S component of the double to have existed at that date and of the same magnitude as at present, but that there was no trace of the N component, although stars down to $16^{m}\cdot0$ were recorded.

During the present autumn six exposures have been made with the reflector, in particular plates R 114, exp. 2 hrs. R 133, exp. 4 hrs., and R 134 and 136, 3 hrs. each, obtained when the object was at a considerable altitude and conditions fairly satisfactory, all clearly divide the double star, and show that the N component is now slightly the fainter of the two.

From plate R 134, October 12, 1912, $11^{h}\cdot7$, the distance of the components is found to be $7''\cdot2$, position angle 180°, mags. $15^{m}\cdot5$ and $15^{m}\cdot3$. The detail diagram of the region indicates all stars to $16^{m}\cdot0$ in the immediate neighbourhood of the Nova which are clearly visible on plates R 133, 134, and 136. The fairly satisfactory plates recently obtained do not show the double star as nebulous, but suggest that there is faint nebulosity between it and B.D. + 56°436, and *s.p.* and *s.* towards the star *i*; the scale of the R plates is, however, too small, $1^{mm} = 106''$, $0\cdot85^{mm}$ between *a* and *b*, to enable several faint stars in close proximity to be distinguished from true nebulosity.

The following estimate of magnitude will afford a check on my personal equation in this respect:—

a, 9·5. *b*, 9·6. *c*, 10·8. *d*, 10·9. *e*, 11·0. *f*, 12·1. *g*, 12·6. *h*, 13·0. *i*, 14·0. *j*, 14·8. *k*, 15·3. Nova, 15·5. *l*, 16·0.

Variable 21, 1912. This object was found on plate R 36, January 9, 1912, $9^{h}\cdot5$, exp. 2 hrs.

Fourteen plates prior to this date do not record any object in its position. Its magnitude on R 36 was estimated at $13^{m}\cdot5$. Unfortunately, this and the neighbouring faint star dots are perfectly circular, which makes it very difficult to distinguish it with certainty from a particular kind of plate defect; it shows some flare, but not so much as neighbouring stars. This would be characteristic of a very red star. It was not recovered until plate R 48, March 7, 1912, $8^{h}\cdot8$, exp. 3 hrs., when a very faint object in the same position was shown with certainty, mag. about 16·0.

The three best plates taken this autumn show the object with certainty, but extremely faint, mag. 16·5. The evidence is, on the whole, strongly suggestive of a temporary rise of brightness, but cannot be regarded as entirely satisfactory.

In connection with the undoubted Nova 87, 1911, and the object 21, 1912, their remarkable proximity to the Nova No. 1 Persei, see p. 34, *Harvard Second Catalogue of Variable Stars*, has only recently come under my notice. I am not able to define the

exact star, if any, in the position of this Nova on my plates, but it must lie in the small circle marked No. 1 Persei on my general index diagram. The facts rather strongly suggest the existence of some special cause of instability in this region.

Variable 28, 1912. The variability of this star was detected by the superposition of plate V 237 when it was near maximum, on V 119 when near minimum. The whole series of 41 V plates is available as evidence, also the 17 Da plates, 10 R plates, and visual observation with the 15-inch reflector on 33 nights between July 15 and Nov. 27, 1912.

The discussion of the plates up to the date of discovery suggested that the period of variation might be about 130 days. The very considerable material collected this autumn indicates, however, that this was much too long, owing to the fact that accidental maxima and minima of a relatively short period were recorded on the plates. It is practically certain that the true period, if regular, is very near 15 days, about equally divided between rise and fall; near maximum the star has, so far, always come up to very near $11^{m}\cdot0$, and about minimum fallen to near $14^{m}\cdot0$; that is to say, it varies from quite conspicuous visibility, to the extreme limit of magnitude which can be glimpsed with the 15-inch reflector, using a Steinheil monocentric eyepiece, power 200. The variable has a companion of about $14^{m}\cdot5$ at 13″ distance, position angle 290°.

The material available points to the star being brighter photographically than visually, particularly near minimum, a feature of interest which will be further investigated.

A new variable star between B.D. + 57°459 and 57°461 Persei. The variability of this star was discovered by superposing plates V 309 and V 26. The evidence of variation at present available comprises the series of 41 V plates, 17 Da plates, 4 R plates, and visual observation with the reflector on 18 nights since September 26, 1912, and leaves no doubt that the star is a long-period variable with a range of photographic magnitude from about $10^{m}\cdot8$ to below $13^{m}\cdot5$ in about 350 days, the recent maximum having occurred on November 29, 1912.

The star is decidedly brighter visually than photographically, and is of a distinctly reddish colour; on the above date, at $9^{h}\cdot5$ with the 15-inch reflector, power 200, it was found to be only slightly less bright than B.D. + 57°459, mag. $9^{m}\cdot3$. The rise and fall are both gradual.

In the region covered by my V plates the Bonn *Durchmusterung* records the existence of 691 stars down to magnitude $9^{m}\cdot2$, and over the same region the *Harvard Second Catalogue of Variable Stars* lists five variables with maxima brighter than $9^{m}\cdot0$, and varying more than one magnitude, *i.e.* 1 variable per 138 stars.

My average V plate, as already stated, contains the record of

over 17,000 stars, of which 16,300 may be taken as permanently below $9^{m}\cdot2$, and of these the observations indicate with certainty that three have varied more than one magnitude but have fallen short of $9^{m}\cdot0$ at maximum, and the Harvard Catalogue contains one more, *i.e.* 1 variable for 4070 stars. Other long-period variables and Novæ of faint maxima will no doubt be found from time to time over this region, but it appears that the above ratios are hardly likely to be very materially altered; they are very significant in relation to the question which the present investigation set out to solve.

There is also the following point:—A good R plate, namely, R 134, exposure 3 hrs., centred near the Nova 87, 1911 Persei, was selected, and the stars on it down to $15^{m}\cdot0$ were carefully counted over three sets of ten squares taken impartially over the whole area. The means of each set are respectively 7·5, 8·5, 8·3 stars per square; taking 8 stars per square to be slightly below the mark, and there are 1700 squares, the number of stars on the plate is 13,600. It covers four square degrees; which gives 3400 stars per square degree.

The region is an absolutely normal specimen of the Milky Way, the stars being thickly sown but not concentrated in any conspicuous cluster. It seems to offer a quite plausible standard whereby a rough estimate of the number of stars down to $15^{m}\cdot0$ in the Milky Way, apart from special clusters, may be made. Taking the average width of the band visible to the eye as 8°, which is a conservative estimate, the figure then arrived at is 9,800,000 stars.

The remarkable stability of this great body of stars is strongly suggested by the facts mentioned above; by the results derived from superposing the R plates on which a variation of 1 magnitude in stars down to $15^{m}\cdot0$ could be quite easily detected, and from which no absolutely certain case of variation has so far been found; and also from the evidence furnished by a very large number—about 500—of plates taken with the portrait-lens cameras about the regions α Aquilæ, α and ϕ Aurigæ, α, β, γ, δ, and No. 1 Cassiopeiæ, α and B.D. $+61^{\circ}2246$ Cephei, M 57 Lyræ, and α and δ Persei since August 1911, and on which all the known visually discovered variables have been rediscovered, but on which no certain case of variation has been detected amongst the fainter stars, although a few are still under observation, as the evidence with regard to them is at present insufficient.

The same brand of plates, Imperial "Flashlight," was used for all exposures up to November 1, 1912; since then some of the exposures have been made on Griffin's "Professional" plates. I have not detected the slightest sign of relative variation in the magnitudes of the stars recorded on these two brands of plates.

The investigation appears to confirm the idea that the Milky Way is composed for the most part of early type stars, which are notably free from periodic fluctuations save where they suffer

eclipse by a satellite. It is perhaps permissible to connect the following facts:—

(1) The Milky Way, composed for the most part of early type stars, is notoriously the habitat of Novæ.
(2) The element hydrogen in the case of our own Sun is notable as resenting confinement within a reversing layer,

and to ask whether the outburst typical of a Nova may be due to a successful though ultimately disastrous effort on the part of this element to resist confinement, as the gradual formation of a denser reversing layer causes an early type star to decline towards the solar stage. The famous Nova Persei of 1901 presented the spectrum of such a star immediately before the outburst of hydrogen placed it spectroscopically in the class of Novæ.

Tatsfield:
1912 *December* 12.

The Nebula H.V. 16 *Andromedæ and the Stars and Nebulous Knots in its Vicinity.* By Mrs. Isaac Roberts. (Plates 6, 7.)

(*Communicated by the Secretaries*).

The region of H.V. 16 Andromedæ was photographed at Starfield, Crowborough, in 1891, 1903, and 1904, and is found, in the Isaac Roberts collection of celestial photographs, on the four reflector plates:

					m		h	m	h	m		
I.R.	1703,	Oct. 2	1891,	Exp.	60	from	0	3	to 1	3	S.T.	Crowborough.
	3189,	Nov. 14	1903	,,	90	,,	22	28	,, 23	58		,,
	3190,	Nov. 25	1903	,,	90	,,	0	0	,, 1	30		,,
	3191,	Jan. 5	1904	,,	90	,,	0	55	,, 2	25		,,

and on the 5-inch camera plates, I.R. 1528–1536–1538, obtained simultaneously with the plates 3189–3190 and 3191.

In the Isaac Roberts Register of Photographic Plates we read as follows:—

1703. N.G.C. 68, H.V. 16 Andromedæ: sky very clear; stars very few on plate and faint; no nebula. Exp. 60^{m}.
3189. Exp. 90^{m}: sky clear, stars round and very numerous; several nebulæ within 3 minutes of arc radius; see Lord Rosse.
3190. Exp. 90^{m}: sky clear, partly moonlight; stars round, not very numerous, nebulæ as above.
3191. Exp. 90^{m}: sky clear; stars round and numerous. Nebulæ H.V. 16 as on 3190–3189.

The region of H.V. 16, G.C. 31 to 37, described by Lord Rosse* as "a curiously mixed group of stars and nebulous knots . . . 6 or 8 stars of about 14–15 magnitude, and several fainter ones. . . . 7 knots, the three northern of which are the brightest," sketched by Mitchell,† was measured by me on the Isaac Roberts measuring apparatus and reduced in accordance with the methods adopted and described in *M.N.*, March 1912, pp. 408–416.

The result of this study, given in the tables and diagram annexed, leads me to believe that the nebula H.V. 16 and the nebulous knots and stars in its vicinity represent, in the evolution of stellar systems, a phase intermediate between the spiral nebulæ and the loose clusters.

The region H.V. 16, compared with the loose cluster H.VII. 48 Cassiopeiæ, N.G.C. 559, photographed on the I.R. Plate 1705 (see Plate 6), presents many of the features belonging to the latter: stars widely scattered, pretty faint in general, grouped along various arcs, the curvature of which increases rapidly from the outer region to the centre of the cluster, which is not well defined. In the central region of the loose cluster H.VII. 48 we find groups of stars presenting the U shape which is so conspicuous in the region of H.V. 16 Andromedæ.

The vacant areas accentuate more strongly the trend of the stars, and seem to follow certain laws. The photograph of the region of H.V. 16 shows two relatively vacant areas directed *sp* to *nf*, situated on either side of the central region depicted on the diagram. The bright stars bordering these vacant areas appear more numerous in the direction *sp* to *nf*. On the contrary, at greater distances from the group H.V. 16, the stars are more numerous in the direction *sf* to *np*, and the vacant areas of the outer regions are elongated *sf* to *np*.

H.V. 16 and the small stars and nebulous knots in its vicinity also present some of the characteristics of the spiral nebulæ. The convolutions of the central region seem to belong to a left-hand spiral. The small stars and nebulous knots 1, 2, 3, 4, 5, 6, *i.e.* the *p* branch of the greater U, seem to form the converging part of the left-hand spiral arm indicated by the stars and knots 36, 35, 34, 33, 32, 31, 30, 29, 27, and forming the inner southern branch of a greater spiral. The small stars, 17, 18, 19, *i.e.* the *f* branch of the smaller *u*, are near the converging point of the northern left-hand arm formed by the stars and knots . . . 25, 24, 23, 22, 21, 20. The central point of the spiral seems to be near knot 9, midway of the *f* arc of the greater U and the *p* arc of the smaller *u*, which intermingle.

The faint nebulæ and nebulous knots at greater distances from the centre, as shown on Plate 6, appear to belong to more distant spiral arms.

Following the trend of the stars, we find faint traces of

* Observations of nebulæ and clusters of stars made with the 6-foot and 3-foot reflectors at Birr Castle from the year 1848 up to the year 1878.

† *Phil. Trans.*, 1861, pl. xxv. fig. 1.

nebulosity more closely distributed along the inner arms. The *p* arc of the greater U is completely immersed in nebulosity, which is densest at knot 3, and extends over the central region of a spiral form, gradually vanishing and blending with the background.

Standard Stars. Plate I.R. *3189.

	Places for 1900·0 of the Standard Stars derived from the Astrophotographic Catalogue.						Adopted Places from which the Constants were derived.	
	Oxford Zone +29°.	R.A.	Decl.	Oxford Zone +30°.	R.A.	Decl.	R.A.	Decl.
		s	″		s	″	s	″
F	526	58·31	31·4	496	58·23	31·4	58·27	31·4
E	430	10·18	36·7	432	10·21	36·6	10·20	36·7
D	454	29·26	17·7	452	29·32	17·5	29·29	17·6
C	441	43·10	7·9	454	43·19	8·6	43·15	8·3
B	466	31·31	18·8	462	31·26	18·6	31·29	18·7
A	507	7·97	29·3	479	7·91	30·3	7·94	29·8
G	433	7·31	4·4	443	7·21	5·1	7·26	4·8
H	478	58·01	33·0	665	58·06	32·6	58·04	32·8
I	460	43·03	36·0	638	42·99	36·9	43·01	36·5

	Measured Rectangular Co-ordinates.		Concluded Positions for 1900·0 of the Standard Stars.						Diameters of Star Images.		Mag.	B.D.	B.D.
	x	*y*	R.A.			Decl.							
	′	′	h	m	s	°	′	″	″	″			
O	0·000	0·000											
F	−29·796	+26·297	0	10	58·30	+29	58	31·0	29	25	8·6	K	+29°31
E	−27·188	−14·608	0	11	10·20	+29	17	36·4	26	24	9·0	K	+29°33
D	−23·037	− 2·918	0	11	29·32	+29	29	17·2	23	20	9·5	...	+29°34
C	−20·030	− 4·053	0	11	43·14	+29	28	8·6	26	24	8·9	K	+29°35
B	− 9·584	+ 3·162	0	12	31·26	+29	35	19·0	23	21	8·4	K	+29°37
A	− 1·690	+18·389	0	13	7·93	+29	50	30·0	30	28	8·0	K	+29°39
G	− 1·689	−10·015	0	13	7·29	+29	22	5·7	15	14	...	...	...
H	+22·230	+11·625	0	14	57·98	+29	43	32·5	24	22	9·1	K	+29°43
I	+32·159	− 2·201	0	15	43·05	+29	29	36·3	27	24	9·0	...	+29°46

The Constants and Concluded Centre of the Plate I.R. *3189.

$t_x = +0·00027$ $t_y = +0·00007$

$i_x = +0·00522$ $i_y = +0·00645$

$\alpha_0 = 0^h\ 13^m\ 15^s·28$ $\delta_0 = +29°\ 32'\ 6''·0$

The Region of H.V. 16 *Andromedæ on I.R.**3189.

	Measured Rectangular Co-ordinates.		Concluded Places for 1900·0.						Diameters of Images.		Intensities of the Nuclei and Outer Region.		N.G.C. H.		H. Kobold, *Annals Strasburg*, 1900, vol. iii.	
	x.	*y.*	R.A.			Decl.			2*a*.	2*b*.					R.A.	Decl.
	′	′	h	m	s	°	′	″	″	″					s	″
38	−3·375	−2·122	0	12	59·71	+29	29	59·9	8	6	14	15	67	L^{d}R 5	59·93	57·2
37	−2·775	−1·660	0	13	2·48	+29	30	27·4	6	5	17	...		...	...	...
26	−2·006	−1·158	0	13	6·03	+29	30	57·3	9	8	11	17	68	H.V. 16	6·30	58·5
39	−1·585	−3·038	0	13	7·92	+29	29	4·3	14	8	14	17	69	L^{d}R 2	8·33	4·1
12	−1·409	+2·143	0	13	8·85	+29	34	15·1	9	6	6	...		...	...	...
4	−1·211	−0·994	0	13	9·69	+29	31	6·8	8	7	7	...		...	...	...
3	−1·122	−0 661	0	13	10·11	+29	31	26·8	8	6	14	17	70	L^{d}R 6	10·46	29·3
27	−1·042	−2·212	0	13	10·44	+29	29	53·7	6	5	14	17		...	...	...
25	−1·067	+3·033	0	13	10·45	+29	35	8·4	7	5	7	8		...	...	...
25$_1$	−0·980	+2·750	0	13	10·84	+29	34	51·4	13	10	3	...		...	...	...
6	−0·902	−1·647	0	13	11·09	+29	30	27·5	6	6	10	17	71	L^{d}R 4	11·39	29·1
2	−0·868	−0·343	0	13	11·28	+29	31	45·8	9	9	6	...		...	...	...
1	−0·631	−0·127	0	13	12·38	+29	31	58·6	6	5	8	14		...	...	...
7	−0·282	−1·427	0	13	13·95	+29	30	40·5	9	9	5	...		...	...	...
11	−0·256	+0·682	0	13	14·12	+29	32	47·0	6	5	10	...		...	...	...
40	+0·045	−4·557	0	13	15·38	+29	27	32·6	10	9	4	...		...	...	...
29	+0·125	−2·993	0	13	15·78	+29	29	6·4	6 36	5 13	14	17	72	L^{d}R 3	15·95	4·5
24	+0·139	+1·880	0	13	15·96	+29	33	58·7	7	6	6	8		...	...	...
23	+0·235	+1·633	0	13	16·40	+29	33	43·9	7	5	16	17		...	...	...
8	+0·287	−1·123	0	13	16·57	+29	30	58·5	5	5	12	17		...	...	...
10	+0·398	−0·119	0	13	17·11	+29	31	58·7	7	5	8	...		...	...	...
9	+0·794	−0·747	0	13	18·91	+29	31	20·9	8	6	18	...		...	...	...
41	+1·107	−4·421	0	13	20·26	+29	27	40·3	6	4	7	15		...	...	...
22	+1·128	+1·178	0	13	20·50	+29	33	16·3	6	5	10	...		...	...	...
13	+1·265	−1·051	0	13	21·07	+29	31	2·5	10	9	4	...		...	...	...
30	+1·436	−3·253	0	13	21·80	+29	28	50·3	9	6	11	...		...	...	...
14	+1·552	−0·617	0	13	22·40	+29	31	28·4	9	8	4	...		...	...	...
21	+1·672	+1·181	0	13	23·00	+29	33	16·2	9	7	4	...		...	...	...
31	+1·790	−3·336	0	13	23·43	+29	28	45·1	5	5	17	...		...	...	...
15	+1·900	−0·197	0	13	24·01	+29	31	53·4	6	4	12	16		...	...	...
42	+2·126	−5·491	0	13	24·92	+29	26	35·7	9	8	4	...		...	...	...
32	+2·180	−3·249	0	13	25·22	+29	28	50·2	9	6	6	17		...	...	...
17	+2·285	−1·703	0	13	25·75	+29	30	22·9	8	8	4	...		...	...	...
20	+2·368	+0·565	0	13	26·19	+29	32	39·0	6	5	12	...		...	...	...
18	+2·701	−1·195	0	13	27·67	+29	30	53·2	6	6	11	...		...	...	...
19	+2·779	−0·183	0	13	28·06	+29	31	53·9	6	6	9	14		...	...	...
33	+3·522	−3·196	0	13	31·39	+29	28	52·8	8	7	6	17		...	...	...
34	+4·689	−1·690	0	13	36·79	+29	30	22·7	28	9	14	17	74		37·31	20·6
43	+4·804	−4·820	0	13	37·24	+29	27	14·7	9	7	5	...		...	...	...
44	+4·937	−5·323	0	13	37·83	+29	26	44·6	11	7	7	14		...	...	...
35	+5·601	−2·385	0	13	40·97	+29	29	40·6	6	6	5	17		...	...	...
36	+5·783	−1·023	0	13	41·85	+29	31	2·2	11	9	4	...		...	...	...
45	+7·859	−3·110	0	13	51·33	+29	28	56·1	13	10	4	...		...	...	...
46	+9·570	−4·519	0	13	59·15	+29	27	30·8	10	8	17	19		...	...	...

The positions given by the first study of I.R. *3189 (made in March 1910), with the constants for the corresponding orientation, are as follows:—

N.G.C.	R.A.	Decl.	R.A.	Decl.
	s	′ ″	s	′ ″
67 L^{d}R 5	59·84	30 0·2	59·72	29 59·8
68 H.V. 16	6·13	57·7	6·04	30 57·1
69 LR 2	8·09	2·7	7·93	4·1
70 L^{d}R 6	10·14	25·6	10·12	26·6
71 L^{d}R 4	11·18	26·4	11·11	27·3
74	37·07	21·6	36·80	22·4
72 L^{d}R 3	15·94	5·0	15·79	6·2

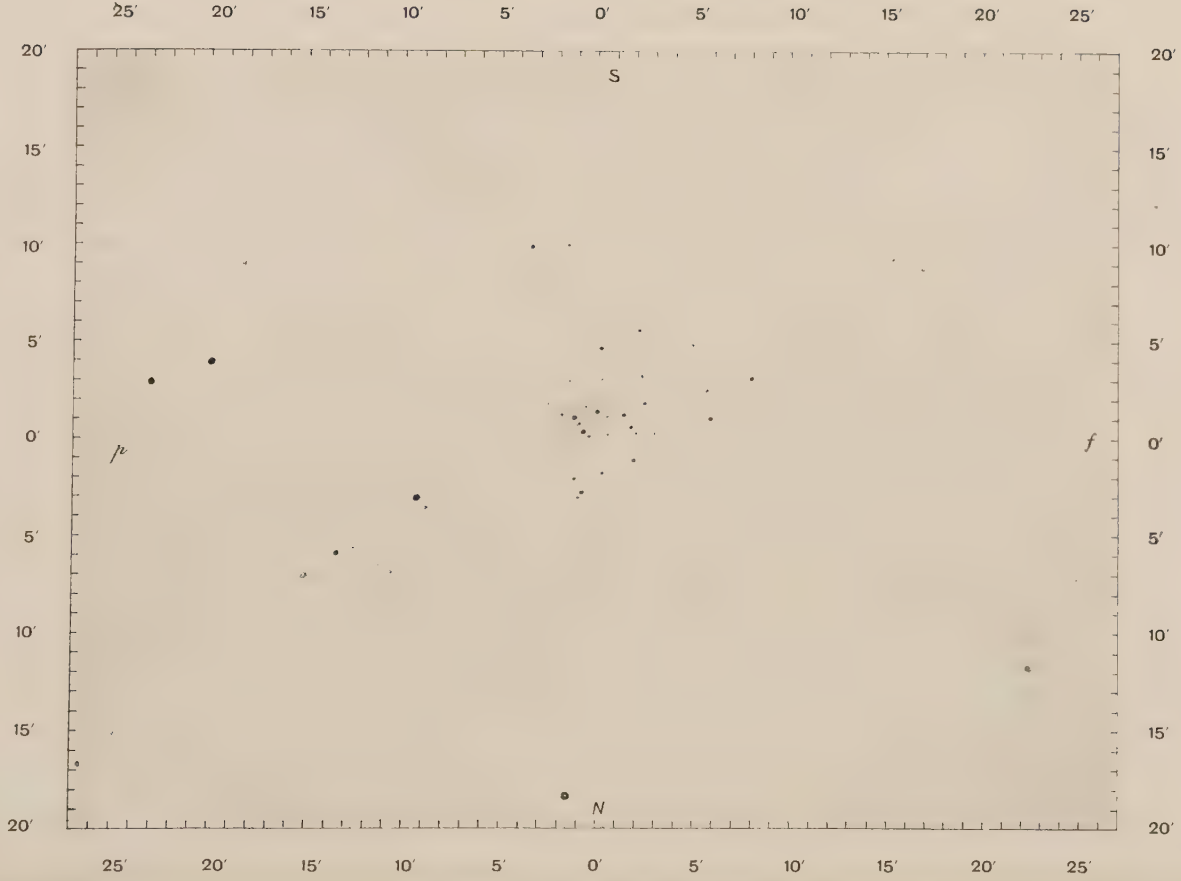
The second and third columns correspond to Study I. (measures of March 1910); the fourth and fifth to Study I. reduced to Study II. (measures of March 1910 reduced to measures of January 1912).

Stars and Nebulous Knots at Greater Distances.

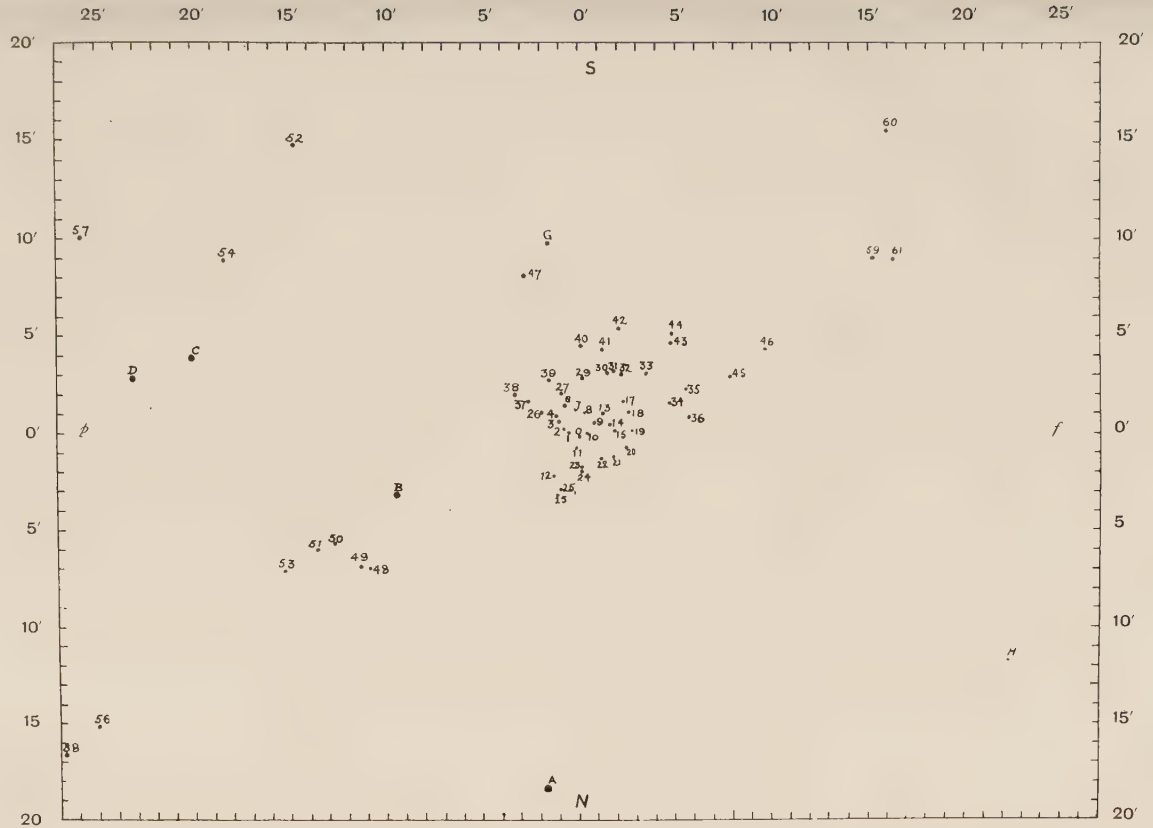
	Measured Rectangular Co-ordinates.		Concluded Places for 1900·0.		Diameters of Images.		Intensities of the Nuclei and Outer Region.	
	x.	*y*.	R.A.	Decl.	2*a*.	2*b*.		
	′	′	h m s	° ′ ″	″	″		
58	−26·650	+16·823	0 11 12·79	+29 49 2·2	14	9	11	13
57	−25·753	−10·128	0 11 16·80	+29 22 4·9	16 71	10 39	17	18
56	−24·891	+15·175	0 11 20·89	+29 47 23·1	9	9	15	17
55	−21·271	−28·347	0 11 37·24	+29 3 51·0	13	10	14	17
54	−18·378	− 8·957	0 11 50·67	+29 23 14·0	7 25	7 15	13	16
53	−15·274	+ 7·017	0 12 5·13	+29 39 11·7	14	13	15	17
52	−14·725	−14·905	0 12 7·37	+29 17 16·3	22	11	16	...
51	−13·708	+ 5·938	0 12 12·32	+29 38 6·5	13	10	6	...
50	−12·753	+ 5·592	0 12 16·71	+29 37 45·7	8	7	17	...
49	−11·286	+ 6·777	0 12 23·48	+29 38 56·3	9 41	8 23	17	18
48	−10·876	+ 6·890	0 12 25·37	+29 39 3·1	8	7	18	...
47	− 2·910	− 8·319	0 13 1·72	+29 23 47·9	7	7	15	18
59	+15·225	− 9·270	0 14 24·96	+29 22 42·7	15	10	6	15
60	+15·834	−15·799	0 14 27·53	+29 16 10·7	9	9	16	17
61	+16·350	− 9·169	0 14 30·13	+29 22 48·3	20	14	18	...
62	+36·029	+25·270	0 16 2·25	+29 57 1·7	13 65	12 40	15 16	17

Definition and Description.

1. Nebulous knot with dense star-like centre involved in the nebulosity which extends over the U arc formed by 1–2–3–4–5–6–7–8–9.
2. Star with diffused margin, involved in nebulosity.
3. Nebulous nucleus with very diffused margin involved in nebulosity which is densest in this region.
4. Star with diffused margin, involved in nebulosity.
5. Faint nebulous knot, not measured, *np* nebula 6, Lord Rosse 4.
6. Nebula, with dense star-like centre and nebulous margin, involved in fainter nebulosity.
7. Star with diffused margin.
8. Star-like centre with nebulous margin, involved in extremely faint nebulosity.
9. Faint nebulous knot, well defined.
10. Small star. 11. Star with diffused margin. 12. Star.
13. Star. 14. Star. 15. Faint star with diffused margin.
16. Very faint nebulous knot, not measured, in the vacant area limited by 13–14–15–17–18–19, presenting traces of very faint nebulosity.
17. Star with three very faint nebulous knots in its *p* region.
18. Small star with diffused margin. 19. Star with diffused margin.
20. Star-like centre with diffused margin; traces of nebulosity in its vicinity.
21. Star with traces of nebulosity in its *f* region.
22. Star with diffused margin. 23. Very faint nebulous knot.
24. Star, in its *nf* region is a very faint nebulous knot.
25. Star.
26. H.V. 16. Dense nucleus with nebulous margin, involved in fainter nebulosity which extends over the U arc in the *f* region and over a faint nebulous knot in the *p* region.
27. Nebulous knot with star-like centre, involved in faint nebulosity; very faint nebulous knots in its *np* and *sf* regions.
28. Nebulous knots on *p* and *f* sides of 27, involved in nebulosity; not measured.
29. Faint elongated nebula with star-like centre, involved in fainter nebulosity; major axis 36″, minor axis 13″.
30. Dense star-like nucleus with diffused margin, involved in fainter nebulosity.
31. Nebulous knot involved in nebulosity which extends over 30 and 32.
32. Star with diffused margin involved in very faint nebulosity.
33. Star with diffused margin; *nf* are very faint nebulous knots.



NEBULA H.V.16 ANDROMEDÆ.


25′ 20′ 15′ 10′ 5′ 0′ 5′ 10′ 15′ 20′ 25′
20′ 15′ 10′ 5′ 0′ 5′ 10′ 15′ 20′
S
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KEY MAP.

34. Faint nebula elongated *sf* to *np*; major axis 28″, minor axis 9″, with nebulous nucleus.
35. Small star. 36. Star with faint nebulous knots in its vicinity.
37. Nebulous knot involved in fainter nebulosity.
38. Nebulous nucleus involved in fainter nebulosity.
39. Dense nucleus involved in nebulosity, nebulous arc in *s* region.
40. Star, traces of nebulosity in *n* region.
41. Small nucleus involved in fainter nebulosity.
42. Small star, nebulous knots in *n* region.
43. Star. 44. Star of nebulous aspect with dense centre, traces of nebulosity in its vicinity.
45. Star. 46. Nebulous knot involved in faint nebulosity.
47. Nebulous nucleus surrounded by extended nebulosity, visible on the I.R. plates 3189–90–91.
48. Faint nebulous condensation, on I.R. plates 3189–90–91.
49. Small elongated nebula with nebulous nucleus, on I.R. plates, 3189–90–91, major axis 41″, minor axis 23″.
50. Faint nebulous nucleus appears to be involved in faint nebulosity.
51. Star, traces of nebulosity in *n* region.
52. Nebulous nucleus, elongated, *sp* to *nf* like the stars in its vicinity.
53. Large nebulous nucleus with diffused margin, on plates 3189–90–91.
54. Star-like centre with nebulosity in *s* and *sp* regions, differs in aspect from the stars in its vicinity. On I.R. plates 3189–90–91; Major axis 25″, minor axis 15″.
55. Nebulous aspect perhaps due to distortion. On I.R. plates 3189–90–91.
56. Small star with diffused margin, faint nebulous knots in *s* region perhaps faint stars. On I.R. plates, 3189–90–91.
57. Nebulous nucleus involved in faint elongated nebulosity, axes 71″, 39″, visible on I.R. plates 3189–90–91.
58. Small star, distorted; nebulous knots in *n* region, perhaps very small stars; small stars between 56 and 58.
59. Star-like nucleus surrounded by nebulosity, nebulous knots in vicinity.
60. Nucleus surrounded by nebulosity, nebulous arc in *s* region, visible on I.R. plates 3189–90–91.
61. Faint nebulous mass, small break in nebulosity. On I.R. plates 3189–90–91.
62. Nucleus involved in nebulosity elongated *sf* to *np*; axes 65″, 40″; stars in vicinity elongated *nf* to *sp*. On I.R. plates 3189–90–91.

Maison de Rosa Bonheur,
By Thomery.
1912 *December* 7.

Note on the Cambridge Magnitude Equation. By F. A. Bellamy, M.A.

A year ago (*M.N.*, lxxii., p. 93) Professor Turner drew attention to a discontinuity in the Cambridge magnitude equation, indicating that a change of method apparently occurred about the year 1878 or 1879.

To ascertain the epoch of the change more exactly the residuals for the single observations were collected as below. Though these single observations are naturally rougher than the means of several, they carry the exact date of observation; the means of two or more observations may be, for instance, a combination of an observation before 1875 with one in 1885, or even later. An inspection of the residuals in ξ seemed to justify six or seven groups being made as follows:—A (zone 1–255), B (256–425), C (426-650), D (651–1000), E (1001–1350), F (1351–2024). The unit adopted in this note is ·0001 of a réseau interval (0″·03).

Residuals in $\Delta\xi$ outside the limits -250 and $+250$ were omitted. The fainter stars (9·2 to 9·5) have been kept separate for obvious reasons and are given in Table I.; the observations of the brighter stars are in Table II. The subscript number shows the number of stars in each group.

TABLE I.

Mean Residuals for the Fainter Stars.

	A.	B.	C.	D.	E.	F.	
Group	1–255	256–425	426–650	651–1000	1001–1350	1351–2024	
Period 1800+	72·4–74·8	74·8–77·1	77·1–79·3	79·3–83·6	83·6–87·1	87·1–96·8	
							Wtd. Mean for Mag.
Camb. Mag. 9·5	-16_{297}	-5_{32}	-50_{32}	-74_{149}	-36_{40}	-43_{48}	-35_{598}
9·4	-20_{28}	-24_{23}	-21_{24}	-44_{103}	-13_{29}	-17_{23}	-30_{230}
9·3	-11_{27}	-18_{33}	-30_{22}	-33_{85}	-20_{35}	-52_{33}	-29_{235}
9·2	$+1_{18}$	-12_{26}	-11_{10}	-32_{36}	-20_{33}	-29_{26}	-20_{149}
Wtd. Mean	−15	−14	−32	−52	−23	−38	−31
In Arc	−0″·45	−0″·42	−0″·96	−1″·56	−0″·69	−1″·14	−0″·93
No. of Stars	370	114	88	373	137	130	1212

TABLE II.

Mean Residuals for the Brighter Stars.

	A.	B.	C.	D.	E.	F	
9·1	-10_5	$+22_5$	$+20_5$	-39_{15}	-3_{24}	-24_{22}	-14_{76}
9·0	-5_{29}	-26_{13}	$+4_5$	-9_{10}	-47_6	-14_7	-13_{70}
>8·9	-40_1	...	$+12_4$	0_6	$+50_2$	-3_9	$+4_{22}$
Wtd. Mean	−7	−13	+12	−22	−8	−17	−11
In Arc	−0″·21	−0″·39	+0″·36	−0″·66	−0″·24	−0″·51	−0″·33
No. of Stars	35	18	14	31	32	38	168

From which we get

Ft.–Bt. Stars	−0″·24	−0″·03	−1″·32	−0″·90	−0″·45	−0″·63	−0″·60

The groups in these two tables show (1) that we cannot obtain the precise epoch this way; (2) that the change was before group C (1877·1), if we may trust the differences for the fainter *minus* the brighter stars; and (3) that the fainter stars alone suggest some time during C (1877·1 to 1879·4) for the change.

It is not easy, in the absence of definite notes by the observer, to say what the change was. In the introduction to the Cambridge A.G.C., p. (6), it is stated that Mr. Graham observed all the transits from 1872 to 1896, except during some revision work in the latest years, when the transits were observed over all seven wires by Miss Walker; (previously, for the greater part of the zone work, not more than three wires, often only one, had been observed). At this stage, as no other note or intimation of any change could be found in the Cambridge Catalogue or the annual reports, I wrote to Mr. A. R. Hinks asking whether there were any unpublished notes by the observer or other information which would explain the changes in the curve, which I had sent him. I give two extracts from one of his letters, dated 1912 Nov. 27: "The whole of the transits up to early in 1890 were taken by Mr. Graham. After that Miss Walker began to observe occasionally, and gradually did more and more, so that by the end of 1893 she was doing it all." . . . "there is no record of any changes in the method of observation, or of the state of the observer's sight. It is known that Graham was going blind in one eye during his later years, that is, for some time before 1892, and it is believed that he altered the eye which he used: but that is uncertain."

Having the definite information that all the transits up to the end of 1889 were by Mr. Graham, 1890–1893 by Mr. Graham and Miss Walker, and all by Miss Walker afterwards, I split up the group F (1887–1896) for the fainter stars into F, G, and H, that is, before 1890, and after 1893, so that the observations from 1887 to 1890 go to the new group F, G includes those from 1890 to 1893, and H those after, we get the revised results as in Table III. and, similarly, for the brighter stars in Table IV.—these are few in number. A to E remain as in Tables I. and II.

TABLE III.

Mean Residuals for the Fainter Stars.

	Revised F.	G.	H.
Group	1351–1543	1544–1762	1763–2024
Period	1887·1–1890·0	1890·0–1893	1893–7
Mag. 9·5	-49_{16}	-70_{27}	$+119_{6}$
9·4	-51_{17}	$+20_{1}$	$+57_{3}$
9·3	-63_{19}	-58_{13}	$+25_{2}$
9·2	-54_{14}	-21_{9}	$+110_{2}$
Wtd. Mean	-54_{66}	-56_{50}	$+88_{13}$
In Arc	−1″·62	−1″·68	+2″·64

TABLE IV.

Bright Stars.

9·1	-33_{13}	-12_{8}	-10_{1}
9·0	-88_{4}	-15_{2}	$+7_{01}$
>8·9	-14_{5}	$+12_{4}$	$+30_{1}$
Wtd. Mean	-38_{22}	$+1_{14}$	$+30_{3}$
In Arc	−1″·14	+0″·03	+0″·90

One might have expected that the elimination of the influence of Miss Walker's observations in the revised group F and of the inclusion of her observations in group G would have largely increased the mean value for F and decreased that for G; as an explanation of the relatively small change it should be repeated that this paper deals only with *single* observations in R.A., and that Miss Walker was mainly engaged upon the re-observation of the single observations by Mr. Graham, so that probably very few stars in the G group in Tables III. and IV. were stars with single observations by Miss Walker.

This is as far as the single observations will permit the discussion to go; the whole material contained in the Catalogue must now be utilised; the analysis into separate years and magnitudes is being proceeded with at the Observatory by means of a card system.

1912 *December* 10.

Observations of the Magnitude of Nova Geminorum No. 2, *made at the Royal Observatory, Edinburgh.* By H. Jameson, B.Sc.

(*Communicated by the Astronomer Royal for Scotland.*)

The following observations of the magnitude of Nova Geminorum No. 2 were made with a 2-inch monocular, except that of March 22, made with 2-inch binoculars, and that of April 27, made with the 2-inch finder of a larger telescope.

The comparison stars used, and their number and magnitude in the Harvard Revised Photometry and the Potsdam Durchmusterung, are given in the following table. The stars *m* and *n* are not found in H.R.P., and their B.D. magnitudes are reduced to the Harvard scale by means of Table C, page xix of T. W. Backhouse's *Catalogue of* 9842 *Stars.*

Comparison Stars and Magnitudes.

Star.	H.R.P. No.	H.R.P. Mag.	P.D. No.	P.D. Mag.
θ Geminorum	2540	3·64	1333	3·85
ρ ,,	2852	4·18	1448	4·46
τ ,,	2697	4·48	1393	4·60
a	2512	5·76	1322	5·87
b	2586	6·01	1350	6·18
c	2896	5·34	1466	5·65
d	2673	6·47	1383	6·50
e	2660	5·60	1378	5·90
f	2665	6·13	1380	6·14
g	2816	5·71	1430	6·01
h	2620	6·46	1363	6·80
k	2757	5·98	1414	6·46
l	2643	5·95	1370	6·17
m (B.D. +32° 1433, mag. 7·0)		6·9	1340	7·22
n (B.D. +31° 1527, mag. 6·7)		6·5	1413	7·08

Magnitudes of the Nova.

Date.	Hour.	Observations.	Deduced mag. Harvard.	Deduced mag. Potsdam.
Mar. 22	9.9	θ3N1a, τ2N1a, ρ2N1a, N1c1a	5·18	5·41
24	11.1	θ1N3a, N=τ, N=ρ+2 grades	4·34	4·54
28	8.9	N=b, N=a+2 grades.	5·99	6·13
28	9.5	N=d	6·47	6·50
31	9.4	N=b, N=a+2 grades	5·99	6·13
Apr. 2	8.4	c2N1a	5·62	5·80
2	9.0	g1N1a, e1N1f	5·81	5·98
6	12.3	b1N1h, N=d	6·36	6·50
8	10.7	N=b, e1N2h, N=k	5·96	6·28
9	9.8	a1N2b	5·84	5·97
9	10.8	e1N1f, c3N1h, l2N1b	6·01	6·24
10	10.3	N=b, a2N1h, k3N1h, f2N1d	6·24	6·44
11	12.1	N=h, N=d, b1N5m, N=n	6·40	6·68
14	10.6	N=h, a1N2m, k1N2n	6·25	6·60
16	9.5	N<a, N<b	<6·0	<6·2
17	11.0	N<a, N<b	<6·0	<6·2
27	9.9	N<m	<6·9	<7·2

Remarks.

Mar. 22. Clear sky, crescent moon setting.
24. Much cloud about, some moonlight.
28. Sky clear, some cloud, strong moonlight.
31. Clear sky, full moon.
Apr. 6. Much cloud about, observations very doubtful.
8. Much cloud about.
9. Much cloud about.
10. Clear sky.
11. Clear sky, air not very transparent.
14. Some cloud about.
16. *a* and *b* can just be seen doubtfully through thin cloud, N cannot.
17. *a* just visible, *b* doubtfully visible, N invisible, through thin cloud.
27. N perceptibly fainter than *m*. Very cloudy, observation made during break in clouds.

Note on R. Cygni. By Heber D. Curtis.

(*Communicated by the Secretaries.*)

In the *Monthly Notices* for May 1912, Mr. Espin quotes observations by Mr. Grover to the effect that this variable is nebulous at minimum. Such a condition would have so important a bearing on theories of stellar variability that it seemed advisable to verify this observation by photography. The star was examined visually with the Crossley reflector on the night of October 11, 1912, when not much brighter than the fourteenth magnitude. It was sharp and clear-cut, and no evidences of nebulosity could be seen. An exposure of two hours was then made, which shows absolutely no trace of nebulosity.

A recent letter from Mr. Espin states that he has found no evidence of nebulous character at this minimum, save on one occasion, when the star appeared somewhat hazy, and that an examination of the variable by Professor Barnard with the Yerkes refractor likewise has shown no sign of nebulosity.

Mount Hamilton:
1912 *November* 7.

Results of Micrometer Measures of Double Stars made with the 28-inch Refractor at the Royal Observatory, Greenwich, in the year 1911.

(*Communicated by the Astronomer Royal.*)

The measures were made with a bifilar position-micrometer on the 28-inch refractor, focal length 28 feet. The power generally employed was 670. The initals in the last column are those of the observers, viz. :—

S.E.	Mr. Eddington.	B.	Mr. Bryant.
S.C.	Mr. Chapman.	W.B.	Mr. Bowyer.
L.	Mr. Lewis.	H.F.	Mr. Furner.

Micrometric Observations of Double Stars at the Royal Observatory, Greenwich.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Σ 3060 ...	0 1	72 25	120·4	3·43	2	8·5	8·7	·838	W.B.
Küstner 3 ...	0 3	70 1	80·8	0·96	3	9·9	9·9	·899	W.B.
* ...	0 3	70 1	48·5	2·75	2	8·5	9·5	·934	W.B.
β 253 ...	0 6	31 59	51·7	0·62	1	8·3	8·5	·085	B.
Σ 7 ...	0 7	34 32	216·0	1·65	1	8·0	8·5	·928	S.C.
Küstner 4 ...	0 12	68 43	131·9	2·12	2	9·5	10·1	·849	W.B.
OΣ 4 ...	0 12	54 1	127·7	0·14	1	7·4	8·1	·085	B.
Krueger 4 ...	0 14	30 48	187·5	2·41	1	8·5	9·0	·928	S.C.
H 1016 ...	0 15	35 6	19·2	4·21	1	10·0	11·0	·928	S.C.
β 1093 ...	0 16	79 31	70·0	0·34	2	7·3	8·2	·449	B.
β 779 ...	0 23	66 55	258·5	0·75	2	8·5	9·0	·888	W.B.
Hussey 1010	0 30	56 39	81·5	1·58	1	9·2	9·2	·928	S.C.
Hussey 411	0 33	67 49	101·4	0·66	3	8·5	8·5	·914	W.B.
Hussey 413	0 42	67 14	244·6	0·78	2	8·0	9·2	·476	H.F.
β 232 ...	0 45	39 51	46·5	0·17	1	8·0	8·5	·085	B.
Σ 67 ...	0 47	79 53	1·0	2·06	2	8·3	9·0	·838	W.B.
			0·6	2·00	1	...		·936	H.F.
Σ 73 ...	0 50	66 52	38·2	1·10	1	6·2	6·8	·819	S.C.
			35·6	0·82	3	...		·866	W.B.
Σ 75 ...	0 50	76 56	273·0	4·92	1	8·6	10·6	·819	S.C.
Σ 78 ...	0 54	85 3	66·0	4·92	2	9·0	9·5	·476	H.F.
β 302 ...	0 54	69 5	118·8	0·56	1	6·7	8·1	·085	B.
β 867 ...	0 56	78 53	176·3	0·92	2	8·1	8·6	·476	H.F.
			172·1	1·37	1	...		·819	S.C.
Σ 82 ...	0 56	81 0	303·8	1·66	1	8·3	9·3	·016	H.F.
			303·8	1·67	2	...		·896	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch.	Obs.
	h m	° ′	°	″			1911	
β 1228 ...	1 1	77 9	271·5	0″·72	1	8·3 8·9	·016	H.F.
			266·1	0·76	1	...	·923	W.B.
			263·5	0·92	1	...	·819	S.C.
Σ 113 ...	1 15	90 58	0·0	1·61	1	6·2 7·2	·016	H.F.
β 4 ...	1 17	78 56	72·7	0·36	1	7·0 7·5	·085	B.
Σ 122 ...	1 22	86 56	328·0	5·85	1	7·9 9·0	·016	H.F.
			325·3	6·23	1	...	·890	W.B.
OΣ 31 ...	1 29	82 15	83·7	3·96	1	6·9 11·0	·016	H.F.
β 507 ...	1 31	63 42	332·2	2·15	1	7·8 10·6	·953	W.B.
Σ 138 ...	1 31	82 49	43·5	1·59	2	7·3 7·3	·838	W.B.
β 509 ...	1 39	80 53	246·3	0·85	2	8·4 8·7	·476	H F.
Σ 149 ...	1 39	50 30	105·8	1·16	1	8·2 9·7	·082	W B.
Σ 157 ...	1 41	51 31	114·8	12·42	1	8·5 9·0	·082	W.B.
Σ 158 ...	1 42	57 17	257·3	1·88	2	8·3 8 8	·475	W.B.
			257·4	2·09	1	...	·953	H.F.
			258·7	2·26	1	...	·830	S.C.
β 510 ...	1 44	74 8	331·1	1·48	1	8·0 12·0	·936	H.F.
β 1313 ..	1 45	63 25	155·5	0·74	2	8·0 9·8	·945	H.F.
Hu. 805 AB	1 47	56 32	163·9	2·44	1	8·8 10·5	·082	W.B.
			160·6	2·72	1	...	·953	H.F.
AC	...		258·4	10·49	1	8·8 10·0	·082	W.B.
Σ 178 ...	1 47	79 48	18·0	3·03	2	7·8 7·8	·476	H.F.
			17·9	2·95	2	...	·918	W.B.
β 260 ...	1 48	75 0	241·1	0 79	2	8·3 9·0	·476	H.F.
Σ 180 ...	1 49	71 9	358·6	8·30	3	4·2 4·4	·441	W.B.
Σ 183 AB ...	1 50	61 38	357·8	0·32	2	7·5 8·2	·491	W.B.
AC ...	...		164·2	5·55	2	7·5 8·8	·491	W.B.
Aitken 819	1 .52	59 25	134·4	0·59	1	7·8 9·3	·953	H.F.
Σ 194 ...	1 54	65 36	269·5	1·27	2	8·0 8·3	·838	W.B.
Σ 196 ...	1 55	69 25	51·0	2·07	2	8·5 11·0	·918	W.B.
Σ 202 ...	1 57	87 40	310·8	2·21	1	2·8 3·9	·923	W.B.
OΣ 38 ...	1 58	48 6	113·8	0·35	1	5·0 6·2	·085	B.
Σ 208 ...	1 59	64 30	96·1	0·38	1	6·2 8·4	·085	B.
			98·1	0·29	2	...	·491	W.B.
Σ 227 ...	2 7	60 6	72·0	3·38	3	5·0 6·4	·927	W.B.
Σ 228 ...	2 8	42 56	108·6	0·66	1	6·7 7·6	·085	B.
Hussey 807	2 9	55 30	146·8	0·53	1	8·4 8·6	·085	B.
Σ 248 ...	2 15	47 38	146·5	1·51	1	8·9 8·9	·819	S.C.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch.	Obs.
	h m	° ′	°	″			1911	
Aitken 962	2 16	60 28	66·4	0·51	1	8·9 9·2	·846	W.B.
β 8 ...	2 17	81 32	205·6	0·99	2	8·3 9·2	·945	H.F.
Hough 216	2 22	59 7	339·6	1·09	1	8·0 10·3	·953	H.F.
Hussey 428	2 23	67 4	59·6	0·69	1	9·2 9·5	·953	H.F.
Hussey 603	2 24	67 31	228·0	5·25	1	8·5 11·8	·953	H.F.
Küstner 10	2 26	57 29	356·3	3·08	1	9·4 10·0	·868	W.B.
OΣ 42 ...	2 27	38 5	137·1	0·28	1	7·0 7·5	·085	B.
Holden 63	2 30	78 34	288·8	0·87	2	9·0 9·4	·907	W.B.
			291·7	1·02	1	...	·830	S.C.
Σ 285 ...	2 33	56 58	168·8	1·62	1	7·0 7·7	·868	W.B.
			170·1	1·90	1	...	·830	S.C.
β 1315 ...	2 34	75 53	129·2	1·58	2	8·3 9·3	·934	W.B.
Hussey 1043	2 34	74 57	240·8	2·72	2	9·0 9·5	·934	W.B.
Hussey 1044	2 34	75 53	131·8	1·54	1	8·1 9·7	·936	H.F.
OΣ 43 ...	2 35	63 46	39·8	1·01	3	7·2 8·8	·370	W.B.
			45·5	1·06	1	...	·830	S.C.
Σ 300 ...	2 39	60 55	306·9	3·26	1	7·9 8·1	·830	S.C.
Hu. 1046 ...	2 40	76 11	92·1	0·98	1	7·5 11·2	·953	H.F.
β 262 ...	2 42	59 19	65·4	1·46	2	8·0 10·0	·133	W.B.
Σ 305 ...	2 42	71 0	315·4	2·98	2	7·3 8·2	·934	W.B.
			317·7	3·12	1	...	·936	H.F.
β 524 ...	2 48	52 1	316·7	0·17	1	6·0 6·7	·085	B.
β 525 ...	2 54	68 45	156·0	0·47	1	7·0 7·0	·016	H.F.
Σ 333 ...	2 54	69 1	201·2	1·36	2	5·7 6·0	·857	W.B.
			202·1	1·34	2	....	·860	S.C.
Σ 334 ...	2 55	83 43	314·5	1·33	1	7·7 8·2	·923	W.B.
OΣ 49 ...	2 55	72 21	61·0	2·17	1	7·0 10·0	·830	S.C.
			62·5	1·67	1	...	·953	H.F.
Hussey 431	2 56	68 43	191·8	0·81	1	9·4 9·7	·953	H.F.
Σ 346 AB ...	3 0	65 6	91·9	0·39	2	6·0 6·0	·934	W.B.
AC ...			358·2	5·15	2	6·0 10·8	·934	W.B.
AG 61 ...	3 2	69 29	34·2	1·05	1	8·8 9·5	·830	S.C.
Σ 355 ...	3 3	81 56	149·6	2·74	1	8·7 9·5	·016	H.F.
Σ 352 ...	3 3	54 53	2·5	3·14	1	8·2 10·3	·964	H.F.
β 1030 ...	3 5	68 36	160·6	0·62	1	8·4 8·4	·953	H.F.
Glasenapp 1	3 6	75 13	268·6	4·13	2	9·3 9·4	·485	H.F.
			268·0	4·40	1	...	·830	S.C.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch. 1911	Obs.
Σ 360 ...	3 6	53 7	135·4	1·96	1	7·8	8·0	·123	S.E.
			129·6	1·89	1	...		·964	H.F.
Hough 500	3 6	54 15	38·6	0·71	1	8·5	9·0	·964	H.F.
OΣ 51 ...	3 7	46 3	305·4	1·31	1	7·9	8·1	·964	H.F.
Hough 502	3 9	54 36	20·7	0·77	1	8·5	9·0	·964	H.F.
OΣ 53 ...	3 12	51 41	220·2	0·58	1	7·2	8·0	·964	H.F.
Σ 381 ...	3 18	69 20	98·0	1·09	1	7·0	8·7	·830	S.C.
			96·7	0·96	3	...		·879	W.B.
			97·6	1·03	1	...		·953	H.F.
Hussey 1058	3 19	50 61	114·4	0·78	1	7·8	8·5	·964	H.F.
Hussey 1059	3 23	52 40	166·7	0·83	1	8·6	13·5	·964	H.F.
Aitken 983	3 26	60 42	306·7	0·54	1	8·5	9·2	·964	H.F.
β 533 ...	3 30	58 37	46·9	0·76	1	7·0	7·0	·964	H.F.
Σ 413 ...	3 30	56 37	128·9	2·58	1	8·5	8·5	·123	S.E.
Σ 425 ...	3 34	56 10	91·7	2·24	1	7·3	7·3	·876	H.F.
Holden ...	3 39	66 15	130·1	5·85	1	10·0	10·0	·830	S.C.
Hough 504	3 39	54 26	186·8	1·08	1	7·8	8·0	·876	H.F.
Σ 442 ...	3 40	67 33	259·4	2·68	1	9·0	9·5	·830	S.C.
OΣ 516 ...	3 44	58 0	47·2	2·28	1	7·2	9·2	·197	W.B.
Σ 476 ...	3 56	51 35	287·1	21·27	1	7·5	8·7	·928	S.C.
Σ 481 AB ...	3 57	62 8	107·9	2·97	1	7·2	10·8	·830	S.C.
AC ...	...		328·2	17·08	1	10·8	9·2	·830	S.C.
OΣ 531 ...	4 2	52 10	127·2	1·73	1	6·5	8·2	·123	S.E.
Σ 499 AB ...	4 5	66 7	285·9	1·45	2	9·2	9·3	·907	W.B.
			291·3	2·12	1	...		·928	S.C.
AC ...	...		280·5	30·12	1	9·2	11·2	·928	S.C.
Σ 520 ...	4 13	67 24	116·1	0·76	2	8·0	8·0	·190	W.B.
OΣ 82 ...	4 18	75 10	95·6	0·76	1	7·0	9·0	·016	H.F.
OΣ 81 ...	4 19	56 15	37·9	4·60	2	6·0	8·8	·207	W.B.
Σ 546 ...	4 22	71 5	184·8	6·78	2	7·7	9·5	·096	W.B.
Hussey 1080	4 24	74 3	258·0	0·34	2	6·5	7·5	·582	W.B.
Σ 562 ...	4 29	67 29	277·9	1·80	3	7·5	11·0	·460	W.B.
Σ 567 ...	4 31	70 4	324·4	1·74	2	8·5	9·0	·096	W.B.
Σ 572 ...	4 33	63 14	200·0	3·64	2	6·5	6·5	·096	W.B.
Hough 332	4 38	69 31	123·6	1·10	2	9·0	9·0	·575	W.B.
Hough 333	4 38	49 55	158·7	2·20	3	9·0	9·3	·131	W.B.
Σ 589 ...	4 40	84 53	293·9	4·39	1	8·0	9·0	·016	H.F.
β 1045 ...	4 52	66 11	8·6	6·26	1	6·0	12·3	·079	L.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Σ 620 ...	4 53	76 11	233·8	3·69	3	8·4	9·4	·393	W.B.
β 1238 ...	4 56	63 36	12·2	1·42	1	8·1	11·3	·079	L.
De 6 ...	4 56	75 37	95·0	0·93	1	8·8	9·2	·225	H.F.
OΣ 93 ...	4 56	85 2	37·6	0·71	1	7·5	9·0	·225	H.F.
Aitken 1024	4 59	60 30	350·6	0·60	1	8·1	8·9	·079	L.
Σ 643 ...	5 3	81 42	119·2	2·35	2	8·5	8·5	·491	W.B.
Σ 644 ...	5 4	52 48	221·7	1·77	1	6·7	7·0	·123	S.E.
Σ 648 ...	5 5	58 5	70·4	4·72	2	7·4	8·1	·200	W.B.
Hough 334	5 12	67 16	181·6	1·79	2	8·2	10·3	·575	W.B.
Hough 226	5 21	62 28	235·9	0·81	1	7·0	7·0	·016	H.F.
			240·3	0·61	2	...		·575	W.B.
β 889 AB	5 22	55 39	228·0	0·89	1	8·5	10·0	·225	H.F.
= AE	...		132·8	18·53	1		14·1	·225	H.F.
Σ 707 AF	...		197·3	27·94	1		13·8	·225	H.F.
Hussey 217	5 24	54 42	266·9	0·54	1	7·0	8·5	·183	W.B.
Aitken 1035	5 24	58 38	120·4	1·15	1	8·5	10·5	·225	H.F.
Σ 716 ...	5 24	64 55	199·9	4·81	2	5·8	6·6	·063	W.B.
Hough 335	5 27	63 17	117·9	3·27	2	9	10·5	·200	W.B.
β 1267 ...	5 29	59 8	212·1	0·68	1	8·5	8·5	·183	W.B.
Σ 742 ...	5 31	68 4	262·6	3·38	2	7·2	7·8	·063	W.B.
			262·0	3·44	1	...		·123	S.E.
Hussey 38	5 40	67 8	148·3	0·48	1	8·6	8·8	·077	S.E.
Σ 787 ...	5 41	68 43	74·0	1·35	2	8·1	8·5	·100	S.E.
			72·4	1·00	3	...		·214	W.B.
Σ 795 ...	5 43	83 34	207·5	1·21	2	6·2	6·2	·083	W.B.
OΣ 123 ...	5 49	29 46	177·0	2·17	2	7·0	8·7	·083	W.B.
Ho. 337 AB	5 50	66 44	116·5	9·31	1	9·0	10·0	·225	H.F.
BC			104·2	1·35	1	9·0	9·2	·225	H.F.
Σ 821 ...	5 53	60 23	7·1	2·08	2	8·0	9·8	·132	W.B.
			4·0	2·12	1	...		·225	H.F.
OΣ 131 ...	6 1	53 43	277·1	1·38	1	7·0	10·2	·225	H.F.
			281·7	1·41	2	...		·259	W.B.
OΣ 132 ...	6 2	52 0	322·8	1·88	1	6·8	10·0	·263	H.F.
β 1058 ...	6 5	66 59	268·4	0·33	2	7·2	7·5	·150	B.
AG 107 ...	6 7	65 33	179·7	1·40	1	9·0	9·2	·077	S.E.
Σ 877 ...	6 9	75 23	263·0	5·54	2	7·2	7·7	·085	W.B.
Lewis 7 ...	6 9	67 24	82·9	3·18	1	9·5	10·0	·214	L.
Σ 888 ...	6 14	61 32	254·8	2·79	3	7·5	9·2	·146	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
β 895 ... = Σ 888 AB	...	...	Possibly elongated at 206° dist. > 0″·1		1	8·5	8·5	·244	W.B.
OΣ 140 ...	6 21	74 26	120·3	2·67	2	7·0	9·5	·117	W.B.
			120·5	2·51	1	..		·225	H.F.
AG 112 ...	6 22	65 25	208·3	2·79	1	9·0	9·1	·263	H.F.
Σ 919 AB ...	6 24	96 58	132·7	7·20	2	5·0	5·5	·117	W.B.
BC ...	...		106·1	2·47	2	5·5	6·0	·117	W.B.
Σ 932 ...	6 29	75 10	324·9	1·96	2	8·2	8·3	·097	W.B.
β 194 ...	6 30	51 56	283·6	1·10	3	8·0	8·5	·261	W.B.
			279·2	1·18	1	...		·263	H.F.
OΣ 149 ...	6 31	62 38	269·6	0·55	3	6·5	9·0	·149	W.B.
AG 116 ...	6 31	51 42	29·6	2·66	1	8·8	9·1	·263	H.F.
Σ 942 ...	6 32	66 17	245·5	3·27	2	9·0	9·2	·117	W.B.
Σ 945 ...	6 34	48 56	276·9	0·71	2	7·1	8·0	·190	W.B.
OΣ 152 ...	6 34	61 39	41·7	0·76	1	6·0	7·8	·077	S.E.
Σ 950 AB ...	6 36	80 1	211·8	2·76	1	6·0	8·8	·167	W.B.
			212·6	2·64	1	...		·263	H.F.
AC ...	...		13·9	16·29	1	6·0	11·2	·167	W.B.
			13·8	17·00	1	...		·263	H.F.
Σ 950² AB	...		45·5	3·83	1	9·0	10·5	·167	W.B.
			45·9	4·33	1	...		·263	H.F.
AD	...		307·9	40·57	1	...		·263	H.F.
Σ 950-950²	6 36	80 1	138·8	73·85	1	6·0	9·0	·263	H.F.
OΣ 156 ...	6 42	71 43	292·9	0·50	1	6·5	7·0	·077	S.E.
			298·7	0·47	4	...		·146	W.B.
Σ 981 ...	6 50	59 43	145·0	2·83	2	8·0	8·0	·190	W.B.
Σ 982 ...	6 50	76 42	157·4	6·53	2	5·4	7·7	·097	W.B.
β 327 ...	6 54	92 54	91·7	0·56	2	7·5	8·0	·152	B.
β 899 AB ...	6 54	71 9	269·5	0·82	1	9·0	9·0	·263	H.F.
AC ...	...		173·8	24·32	1		10·0	·263	H.F.
AD ...	...		47·5	40·68	1		9·0	·263	H.F.
β 1022 ...	6 55	62 36	298·2	0·42	2	8·5	8·5	·152	B.
Hu. 454 AB	7 0	68 11	217·7	2·01	1	9·1	11·3	·263	H.F.
AC	...		45·7	13·12	1	9·1	10·3	·263	H.F.
OΣ 165 ...	7 3	73 56	34·5	5·16	1	5·0	10·7	·263	H.F.
Σ 1037 ...	7 7	62 37	291·0	0·53	1	7·1	7·1	·077	S.E.
			293·9	0·45	4	...		·145	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
OΣ 166 ...	7 7	62 37	107·2	15·89	3	7·1	12·0	·133	W.B.
OΣ 170 ...	7 13	80 32	107·7	1·51	2	7·5	7·5	·117	W.B.
Σ 1066 ...	7 15	67 51	212·1	6·45	1	3·2	8·2	·245	H.F.
Σ 1068 ...	7 15	70 27	349·4	3·78	2	8·3	9·0	·117	W.B.
Σ 1081 ...	7 19	68 22	228·6	1·47	3	7·8	8·5	·169	W.B.
Σ 1110 ...	7 29	57 55	220·9	5·44	2	2·7	3·7	·211	W.B.
			221·4	5·66	1	...		·252	L.
Σ 1130 ...	7 37	80 5	165·7	1·13	3	8·4	8·9	·168	W.B.
OΣ 182 ...	7 48	86 22	32·9	0·85	3	7·0	7·5	·143	W.B.
OΣ 185 ...	7 53	88 38	32·5	0·44	1	6·8	7·0	·162	B.
Σ 1171 ...	7 56	66 10	329·5	2·52	3	6·2	10·7	·239	W.B.
			327·4	2·32	1	...		·263	H.F.
Σ 1175 ...	7 58	85 36	230·2	1·72	1	7·8	9·7	·167	W.B.
β 581 ...	7 59	77 27	303·9	0·36	1	8·0	8·0	·162	B.
Σ 1177 ...	8 0	62 13	350·7	3·56	1	6·5	7·4	·245	H.F.
Σ 1179 AB	8 0	77 40	203·8	20·84	1	8·5	8·5	·274	W.B.
β 582 =BC	...		55·1	3·71	1		12·0	·274	W.B.
Σ 1181 ...	8 1	81 33	136·9	4·79	2	8·0	9·5	·132	W.B.
Σ 1182 ...	8 1	83 55	72·3	4·47	2	7·0	9·0	·132	W.B.
Σ 1185 ...	8 2	88 23	97·6	3·64	1	8·8	9·7	·167	W.B.
Hussey 850	8 3	52 10	352·3	0·59	2	8·7	9·1	·352	W.B.
Σ 1194 ...	8 6	87 49	317·0	2·85	1	8·7	10·4	·167	W.B.
Σ 1197 ...	8 7	60 11	102·8	1·61	2	8·2	9·0	·190	W.B.
Σ 1196 AB	8 7	72 4	325·0	1·00	3	5·0	5·7	·251	W.B.
			327·3	0·92	1	...		·329	L.
AC...	...		111·6	4·93	3	5·0	5·5	·251	W.B.
BC...	...		118·1	5·88	3	5·7	5·5	·251	W.B.
Σ 1200 ...	8 9	39 3	359·9	8·07	1	8·5	8·5	·350	W.B.
* ...	8 11	57 26	212·8	4·82	2	8·8	9·2	·270	W.B.
Σ 1211 ...	8 12	50 43	124·5	0·89	2	8·7	9·2	·308	W.B.
Σ 1205 ...	8 12	33 16	171·4	0·85	1	8·5	8·8	·350	W.B.
Σ 1212 ...	8 12	58 53	236·1	5·35	2	8·2	9·7	·270	W.B.
Hussey 625	8 12	56 53	350·2	1·51	2	8·8	11·2	·308	W.B.
Hussey 855	8 17	76 34	227·3	0·95	1	9·2	10·8	·263	H.F.
Σ 1218 ...	8 18	66 32	269·0	3·88	2	8·5	10·0	·190	W.B.
Σ 1224 ...	8 21	65 10	44·1	5·88	2	6·0	7·1	·255	W.B.
			43·9	5·72	1	...		·309	L.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Σ 1223 ...	8 21	62 46	218·4	4·94	1	6·0	6·5	·077	S.E.
			215·2	4·86	2	...		·255	W.B.
			215·6	5·13	1	...		·309	L.
			216·8	5·20	1	...		·263	H.F.
Σ 1225 ...	8 22	38 30	192·0	3·47	1	8·5	8·5	·353	W.B.
Σ 1228 ...	8 22	62 9	350·0	8·98	3	8·0	8·5	·208	W.B.
Σ 1239 ...	8 26	52 11	290·0	12·71	2	8·5	9·8	·308	W.B.
Σ 1235 ...	8 27	32 46	84·7	1·25	1	8·0	10·0	·353	W.B.
Σ 1242 ...	8 30	42 34	170·0	2·46	2	8·6	9·3	·308	W.B.
AG 154 ...	8 32	66 26	361·7	1·62	2	9·1	9·3	·169	W.B.
Σ 1244 ...	8 32	47 53	1·0	3·39	2	8·2	9·8	·308	W.B.
Σ 1251 ...	8 34	48 23	27·6	6·04	2	9·0	9·7	·346	W.B.
Σ 1262 ...	8 36	65 50	199·9	7·10	2	8·0	10·0	·181	W.B.
Küstner 32	8 36	70 24	164·2	1·89	2	8·4	10·2	·169	W.B.
Σ 1265 ...	8 39	76 3	309·3	5·76	2	8·4	10·8	·169	W.B.
Σ 1259 ...	8 41	51 10	341·5	4·85	2	8·5	9·0	·308	W.B.
Σ 1273 AB	8 42	83 14	211·3	0·26	2	4·0	5·5	·348	W.B.
$\frac{AB}{2}C$	...		238·9	3·49	2	3·8	7·8	·348	W.B.
Σ 1274 ...	8 43	51 20	42·5	9·22	2	7·0	8·7	·308	W.B.
Σ 1278 ...	8 43	40 20	124·2	8·36	2	8·0	10·0	·352	W.B.
Σ 1279 ...	8 44	50 5	90·8	1·45	2	8·3	8·3	·308	W.B.
Σ 1275 ...	8 44	32 9	196·3	1·43	1	8·0	8·0	·353	W.B.
AG 157 ...	8 45	66 32	77·0	2·05	1	9·3	9·5	·077	S.E.
Σ 1288 ...	8 47	61 13	258·5	7·45	4	8·9	9·0	·335	W.B.
Σ 1290 ...	8 47	85 12	311·4	3·14	1	8·0	9·9	·183	W.B.
Σ 1289 ...	8 49	46 4	5·7	3·76	2	7·7	8·5	·308	W.B.
Hussey 718	8 55	57 14	193·5	0·58	1	8·7	8·9	·350	W.B.
Σ 1300 ...	8 56	74 22	195·2	5·02	2	8·7	8·8	·155	W.B.
Σ 1301 ...	8 56	63 21	357·1	9·90	1	8·5	9·0	·350	W.B.
Σ 1333 ...	9 13	54 15	40·3	1·78	1	6·6	6·9	·348	L.
Σ 1334 ...	9 13	52 48	238·0	3·04	1	4·0	6·7	·348	L.
Σ 1338 ...	9 15	51 23	175·1	1·49	2	7·0	7·2	·308	W.B.
			170·3	1·53	1	...		·348	L.
AG 165 ...	9 18	67 27	17·8	1·28	1	9·1	9·3	·077	S.E.
			13·3	1·17	3	...		·169	W.B.
OΣ 201 ...	9 19	61 43	226·2	1·36	1	7·5	9·0	·077	S.E.
			221·7	1·29	2	...		·155	W.B.
			224·8	1·44	1	...		·309	L.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
β 105 ...	9 19	63 26	210·8	2·95	1	4·9	10·7	·309	L.
Σ 1348 ...	9 20	83 16	319·8	1·73	2	7·5	7·6	·155	W.B.
Aitken 223	9 21	60 59	3·6	2·00	1	10·0	10·2	·309	L.
Σ 1355 ...	9 23	83 22	335·1	2·42	2	7·2	7·2	·163	W.B.
Σ 1356 ...	9 24	80 33	121·8	1·00	2	6·2	7·0	·170	W.B.
Aitken 224	9 27	59 9	228·3	1·06	1	8·8	10·0	·309	L.
Σ 1372 ...	9 32	73 22	62·3	0·58	1	8·2	8·3	·077	S.E.
Σ 1375 ...	9 36	55 0	303·9	7·30	1	8·0	9·8	·353	W.B.
Lewis 10 ...	10 10	71 40	7·0	1·85	1	8·0	8·5	·309	L.
Σ 1417 ...	10 10	70 26	259·7	2·20	1	8·2	8·3	·285	H.F.
OΣ 215 ...	10 11	71 49	205·0	0·97	1	7·0	7·2	·077	S.E.
			200·5	0·90	1	...		·263	H.F.
			202·8	0·78	2	...		·275	W.B.
			208·9	1·09	1	...		·309	L.
Hussey 875	10 13	52 2	74·4	0·87	3	7·0	9·8	·350	W.B.
Σ 1420 ...	10 13	50 26	323·6	2·12	2	8·2	9·9	·308	W.B.
Σ 1424 ...	10 15	69 42	113·3	3·59	1	2·0	3·5	·285	H.F.
Σ 1431 ...	10 21	80 46	68·5	3·08	1	7·5	9·2	·167	W.B.
OΣ 217 ...	10 22	72 19	147·5	0·66	1	7·3	9·8	·167	W.B.
			151·5	0·75	1	...		·285	H.F.
OΣ 220 ...	10 24	79 23	69·4	1·18	1	7·1	9·0	·167	W.B.
Hussey 880	10 26	52 25	120·3	0·66	1	9·0	9·7	·348	L.
Σ 1442 ...	10 28	51 51	159·1	4·94	2	9·0	9·0	·393	W.B.
Σ 1450 ...	10 30	80 53	154·7	1·86	1	6·0	8·7	·285	H.F.
Σ 1459 ...	10 35	51 7	153·3	5·07	2	8·0	8·5	·352	W.B.
Σ 1460 ...	10 35	47 22	166 0	3 29	2	8·1	8·1	·382	W.B.
Σ 1461 ...	10 37	42 52	135·7	9·03	2	8·2	9·7	·383	W.B.
Σ 1463 ...	10 38	42 50	256·8	7·61	2	8·5	9·0	·383	W.B.
Σ 1467 ...	10 40	44 33	293·3	3·84	2	8·0	10·7	·383	W.B.
Hough 532	10 40	51 2	314·9	1·10	1	8·0	12·0	·350	L.
OΣ 229 ...	10 43	48 23	314·6	1·10	1	6·7	7·1	·348	L.
Σ 1487 ...	10 51	64 47	108·8	6·36	1	5·0	7·0	·285	H.F.
Hough 47 BC	10 58	53 51	147·4	1·13	1	9·1	9·2	·348	L.
Σ 1504 ...	10 59	85 53	288·6	1·16	1	7·5	7·6	·359	H.F.
Σ 1511 ...	11 2	78 36	288·0	7·86	1	8·5	8·8	·359	H.F.
H 2562 ...	11 6	58 21	313·6	2·33	1	9·5	12·0	·386	L.
Σ 1523 ...	11 13	57 57	124·3	3·14	1	4·0	4·9	·386	L.
			122·6	2·86	1	...		·372	S.E.
			123·1	2·78	2	...		·443	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Σ 1536 ...	11 19	78 58	50·1	1·89	1	3·9	7·1	·359	H.F.
Σ 1543 ...	11 24	50 10	359·7	5·54	1	5·2	8·2	·520	L.
OΣ 234 ...	11 26	48 13	338·3	0·35	1	7·0	7·4	·433	W.B.
			334·4	0·37	1	...		·520	L.
Hussey 727	11 28	40 3	192·8	1·03	3	8·8	9 2	·401	W.B.
AG 175 ...	11 30	88 0	186·0	2·10	1	8·6	8·9	·359	H.F.
Hussey 887	11 30	54 6	300·2	1·44	1	8·2	11·0	·520	L.
Σ 1555 ...	11 32	61 43	178·3	0·26	3	6·4	6·8	·382	W.B.
			184·2	0·18	1	...		·386	L.
OΣ 237 ...	11 34	48 21	260·8	1·21	2	7·4	9·0	·348	W.B.
Aitken 678	11 35	64 12	158·0	1·03	2	7·6	11·3	·381	W.B.
Σ 1569 ...	11 40	50 30	320·6	3·64	1	8·3	10·2	·520	L.
OΣ 241 ...	11 52	54 3	129·5	1·42	4	6·5	8·4	·374	W.B.
Aitken 681	11 59	64 24	131·8	0 39	2	8·9	9·3	·426	W B.
Aitken 682	12 0	65 23	335·5	0·33	2	7·5	9·0	·426	W.B.
Σ 1601 ..	12 2	50 40	313·8	2·16	2	8·5	9·7	·374	W.B.
Σ 3078 ...	12 5	78 12	304·9	9·58	1	8·2	11·0	·359	H.F.
Σ 1606 ...	12 6	49 36	326·9	0·94	5	6·3	7·0	·395	W.B.
Σ 1613 ...	12 8	53 44	10·8	1·30	2	8·5	8·8	·426	W.B.
H 570 ...	12 9	68 12	111·3	2·59	1	8·8	13·0	·386	L.
Σ 1620 ...	12 11	80 28	80·1	1·97	1	8·5	10·0	·359	H.F.
Hussey 737	12 17	85 57	223·8	2·50	1	9·0	9 3	·359	H.F.
Σ 1639 ...	12 20	63 55	343·6	0 47	1	6·7	7·9	·358	L.
			343·9	0·39	3	...		·377	W.B.
Σ 1642 ...	12 21	44 46	181·1	2·86	1	8·0	8·8	·520	L.
Σ 1643 ...	12 23	62 28	35·4	2·36	1	8·7	9·2	·386	L.
			33·9	1·94	2	...		·405	W.B.
β 1324 ...	12 25	59 59	220·1	2·55	3	9·3	9·9	·422	W.B.
Σ 1672 ...	12 38	55 42	313·9	4·22	1	8·0	9·2	·520	L.
Σ 1687 ...	12 49	68 16	95·9	1·30	1	5·2	8·0	·386	L.
			91·6	1·10	3	...		·416	W.B.
Σ 1696 ...	12 53	59 9	202·7	3·27	2	8·0	8·2	·405	W.B.
Σ 1699 ...	12 54	62 2	362·9	1·52	2	7·8	7·8	·426	W.B.
Σ 1714 ...	12 59	65 53	126·9	2·95	2	8·8	9·2	·423	W.B.
Lewis 12 ...	13 3	62 35	353·3	0·94	1	9·0	9·5	·386	L.
OΣ 260 ...	13 4	62 35	136·3	0·78	1	7·9	8·3	·386	L.
OΣ 261 ...	13 8	57 27	344·4	1·64	2	6·9	7·4	·423	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Σ 1730 ...	13 8	52 37	334·1	1·74	2	8·4	10·1	·423	W.B.
Hussey 644	13 16	41 45	87·7	1·38	1	8·4	9·2	·520	L.
Hough 260	13 19	60 18	330·1	0·58	3	8·2	8·2	·391	W.B.
OΣ 266 ...	13 24	73 49	342·6	1·56	2	7·3	7·8	·400	W.B.
OΣ 269 ...	13 29	54 38	229·3	0·29	2	6·5	7 0	·411	B.
			221·8	0·23	3	...		·458	W.B.
β 932 ...	13 30	102 45	91·2	0·36	1	6·1	6 6	·392	B.
β 933 ...	13 30	56 24	29·4	2·38	3	8·4	8·8	·450	W.B.
Σ 1760 ...	13 30	63 16	66·8	8·32	1	8·0	8·0	·372	S.E.
Σ 1768 ...	13 33	53 15	125·1	1·27	3	5·0	8·5	·465	W.B.
β 934 ...	13 34	39 5	87·4	1·16	1	9·0	9·2	·520	L.
Σ 1769 ...	13 34	50 22	30·3	2·26	2	7·2	9·7	·449	W.B.
β 612 ...	13 35	78 48	35·4	0·13	2	6·0	6·0	·411	B.
Hussey 645	13 35	68 5	17·9	0·74	1	9·5	9·5	·457	W.B.
β 801 ...	13 42	78 43	325·8	2·48	1	8·1	10·9	·438	H.F.
Σ 1783 ...	13 42	48 31	48·3	2·26	2	7·8	10·0	·468	W.B.
Σ 1785 ...	13 45	62 34	326·8	1·81	1	7·2	7·5	·438	H.F.
β 937 ...	13 53	55 8	294·6	0·80	3	8·1	8·3	·422	W.B.
Aitken 687	13 56	61 8	308·9	0·89	4	9·2	9·3	·458	W.B.
Aitken 569	13 57	64 13	114·4	0·46	4	9·0	9·3	·458	W.B.
AG 192 ...	13 59	86 52	8·2	3·09	1	9·0	10·0	·438	H.F.
OΣ 276 ...	14 4	52 50	197·8	0·42	3	7·5	8·3	·422	W.B.
$\frac{AB}{2}$–C ...	...		74·4	9·65	2	..	10·0	·423	W.B.
OΣ 277 ...	14 8	60 52	360·7	0·33	4	7·8	8·0	·476	W.B.
OΣ 278 ...	14 9	45 24	69·2	0·28	2	7·5	7·7	·426	W.B.
			76·8	0·29	3	...		·443	B.
β 224 ...	14 9	77 1	63·7	0·77	1	8·9	9·3	·438	H.F.
Σ 1819 ...	14 11	86 27	346·6	1·13	2	7·9	8·0	·427	W.B.
Σ 1826 ...	14 12	42 36	313·0	4·54	1	8·2	9·2	·520	L.
Σ 1829 ...	14 12	39 8	152·6	6·42	1	7·7	8·2	·520	L.
Howe 32 ...	14 12	66 13	193·4	4·59	2	9·1	9·5	·488	W.B.
Aitken 147	14 14	38 35	103·6	0·62	1	8·5	9·8	·520	L.
β 1271 ...	14 15	35 2	352·3	2·90	1	6·8	12·0	·520	L.
Σ 1834 ...	14 17	41 5	61·1	0·19	2	7·1	7·2	·493	W.B.
			102·2	0·16	3	...		·430	B.
Σ 3086 ...	14 28	72 18	272·1	5·78	1	9·0	10·0	·452	W.B.
Aitken 570	14 28	62 55	117·1	0·23	3	6·3	6·5	·443	B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Σ 1863 ...	14 35	38 2	84·5	0·64	2	7·1	7·4	·411	B.
Σ 1865 ...	14 37	75 53	137·2	0·42	1	3·5	3·9	·329	L.
			137·2	0·64	2	...		·411	B.
Σ 1879 ...	14 42	79 58	122·5	0·73	2	7·7	8·5	·411	B.
OΣ 285 ...	14 42	47 15	107·6	0·39	2	7·1	7·6	·411	B.
Σ 1883 ..	14 44	83 41	231·8	0·39	2	7·0	7·0	·411	B.
Σ 1888 ...	14 47	70 32	135·9	2·26	1	4·7	6·6	·438	H.F.
OΣ 287 ...	14 48	44 42	322·8	0·85	2	7·5	7·6	·529	W.B.
OΣ 288 ...	14 49	73 55	186·4	1·43	2	6·4	7·1	·523	W.B.
Hussey 745	15 0	69 48	22·7	0·51	1	7·5	9·0	·438	H.F.
Σ 1908 ...	15 1	55 11	146·9	1·36	2	8·2	9·2	·526	W.B.
Σ 1909 ...	15 1	42 0	247·6	4·11	1	5·2	6·1	·616	L.
* ...	15 0	42 5	64·8	12·42	1	7·0	12·5	·616	L.
Σ 1910 ...	15 3	80 26	207·0	4·09	1	7·0	7·0	·438	H.F.
Σ 1912 ...	15 5	84 27	335·5	6·98	1	8·5	9·3	·438	H.F.
Aitken 690	15 5	61 32	355·4	0·99	3	9·0	9·5	·541	W.B.
Aitken 1116	15 7	79 32	27·9	0·42	2	8·1	8·1	·411	B.
Hough 60 ...	15 10	54 47	29·4	0·30	3	7·5	7·6	·446	W.B.
Σ 1923 ...	15 10	75 13	13·1	4·86	2	8·5	9·2	·523	W.B.
Σ 1926 ...	15 12	51 22	255·9	0·97	2	6·1	8·4	·597	L.
OΣ 295 ...	15 12	52 50	131·2	0·99	2	7·4	9·0	·597	L.
Σ 1932 ...	15 14	62 51	354·2	0·74	3	5·6	6·1	·443	B.
			350·1	0·58	2	...		·559	L.
Σ 1937 ...	15 19	59 24	218·3	0·99	2	5·5	6·0	·526	W.B.
			219·5	1·43	2	...		·545	S.C.
			225·7	1·05	2	...		·559	L.
Σ 1938 ...	15 21	52 20	57·7	1·21	2	6·7	7·3	·597	L.
Σ 1941 ...	15 22	63 3	223·5	1·40	2	8·7	8·7	·526	W.B.
Σ 1944 ...	15 23	83 35	330·3	1·01	1	7·5	8·1	·438	H.F.
Aitken 82 ...	15 23	65 46	322·4	1·33	1	8·5	9·3	·438	H.F.
OΣ 296 ...	15 23	45 40	300·6	1·20	1	7·0	8·6	·616	L.
Lewis 13 ...	15 25	43 29	337·3	3·33	1	7·5	9	·616	L.
Hussey 150	15 25	43 29	24·8	4·57	1	9·0	9·4	·438	H.F.
Σ 1950 ...	15 26	64 11	92·6	3·02	4	6·7	8·2	·479	W.B.
Hussey 1163	15 27	51 32	272·0	0·35	3	8·2	8·5	·589	W.B.
Hussey 577	15 29	69 57	28·7	0·34	3	8·0	8·0	·443	B.
Σ 1954 ...	15 31	79 10	9·1	3·86	2	3·2	4·1	·544	S.C.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch. 1911	Obs.
	h m	° ′	°	″					
Σ 1957 ...	15 32	76 47	158·9	0·87	1	7·9	9·6	·438	H.F.
			145·6	1·00	2	...		·523	W.B.
OΣ 298 ...	15 33	49 54	193·4	1·34	1	7·0	7·3	·616	L.
Σ 1964 BC	15 35	53 28	8·0	1·40	2	7·3	8·8	·597	L.
Hussey 1167	...		84·9	1·00	2	6·8	12·5	·597	L.
AG 197 ...	15 36	68 26	126·2	2·95	1	9·0	9·1	·438	H.F.
			127·5	2·90	2	...		·518	W.B.
Σ 1965 ...	15 36	53 4	123·9	5·77	1	4·9	5·9	·531	S.C.
Hussey 580	15 38	70 3	56·5	0·19	3	5·0	5·0	·443	B.
Σ 1967 ...	15 39	63 25	116·5	0·65	2	4·0	7·0	·469	B.
			113·2	0·58	3	...		·541	W.B.
			116·0	0·58	2	...		·559	L.
			112·3	0·85	1	...		·570	H.F.
β 619 ...	15 39	76 3	4·3	0·61	1	6·9	7·7	·438	H.F.
β 621 ...	15 47	45 13	48·2	0·44	3	7·5	8·0	·589	W.B.
			49·1	0·71	1	...		·761	H.F.
β 810 ..	15 48	47 16	87·3	1·03	1	8·5	11·2	·761	H.F.
Σ 1988 ...	15 53	77 15	80·6	2·23	3	7·5	8·2	·467	W.B.
			81·7	2·30	2	...		·504	H.F.
OΣ 303 ...	15 57	76 28	148·3	0·81	2	7·4	7·9	·475	W.B.
AG 200 ...	15 58	50 9	211·4	3·27	1	9·3	9·5	·761	H.F.
Σ 1998 ...	15 59	101 8	335·0	0·56	2	4·9	5·2	·411	B.
β 812 ...	16 3	72 52	117·7	0·76	1	8·2	8·3	·438	H.F.
			120·8	0·62	2	...		·500	W.B.
β 949 ..	16 4	99 52	13·3	0·17	2	7·6	7·7	·411	B.
OΣ 306 ...	16 8	55 23	35·2	0·34	3	7·2	8·7	·589	W.B.
Σ 2021 ...	16 9	76 14	337·6	3·87	3	6·7	6·9	·508	H.F.
			339·2	4·13	2	...		·544	S.C.
Σ 2022 ...	16 9	63 6	138·6	2·38	2	6·2	9·8	·518	W.B.
			142·4	2·57	1	...		·539	L.
Σ 2032 AB	16 11	55 55	220·6	5·09	3	5·0	6·1	·579	S.C.
			215·1	4·95	2	...		·597	L.
			215·7	4·79	1	...		·761	H.F.
AC	...		83·2	65·24	2	5·0	10·5	·597	L.
Hussey 480	16 12	70 3	255·6	1·38	1	9·0	10·2	·438	H.F.
Hussey 661	16 15	40 29	125·4	0·80	1	9·0	9·2	·761	H.F.
Hussey 1172	16 15	57 53	327·8	1·67	1	9·1	10·0	·761	H.F.
OΣ 309 ...	16 16	48 7	247·0	0·35	2	7·5	7·7	·469	B.
Hussey 481	16 17	66 48	217·8	0·43	3	7·3	9·2	·543	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance	No. of Nights.	Mags.	Epoch.	Obs.
	h m	° ′	°	″			1911	
β 951 ...	16 20	56 26	47·0	1·00	2	8·2 8·7	·531	W.B.
			51·3	0·80	1	...	·761	H.F.
OΣ 310 ...	16 22	51 53	225·5	3·15	1	7·6 10·2	·761	H.F.
β 815 ...	16 24	46 53	334·5	10·72	1	8·1 10·4	·761	H.F.
β 813 ...	16 24	63 16	167·5	1·14	2	8·4 8·4	·544	S.C.
Σ 2049 ...	16 24	63 49	210·4	1·18	2	6·5 7·5	·544	S.C.
Σ 2052 ...	16 25	71 24	87·8	0·98	1	7·5 7·5	·539	L.
Σ 2055 ...	16 26	87 49	73·2	1·21	2	4·0 6·1	·527	S.E.
Σ 2057 ...	16 27	70 30	265·1	4·98	2	8·5 8·8	·700	W.B.
Σ 3105 ...	16 27	96 50	22·5	0·38	2	7·7 7·7	·412	B.
Hussey 1173	16 27	55 55	60·2	0·19	3	8·4 8·7	·564	B.
Σ 2058 ...	16 28	70 30	348·0	1·89	2	9·0 9·5	·642	W.B.
β 816 ...	16 28	56 18	224·4	5·23	1	6·3 11·8	·685	H.F.
OΣ 313 ...	16 30	49 42	147·5	0·95	3	7·2 7·8	·564	B.
Σ 2061 ...	16 30	58 54	23·0	2·55	3	7·1 9·9	·521	W.B.
			23·0	2·65	1	...	·761	H.F.
β 952 ...	16 32	52 55	148 7	3·29	2	8·0 10·3	·723	H.F.
Σ 2078 ...	16 34	36 54	111·4	3·88	3	5·0 6·0	·579	S.C.
OΣ 314 ...	16 35	69 22	234·2	3·69	1	7·2 10·1	·685	H.F.
Hussey 486	16 36	67 6	137·9	1·04	1	9·0 10·0	·685	H.F.
Hussey 487	16 38	67 59	21·7	0·51	4	9·0 9·0	·526	B.
Σ 2084 ...	16 38	58 15	135·8	1·16	3	3·0 6·5	·543	W.B.
			135·3	1·14	4	...	·555	B.
			144·9	1·22	3	...	·578	L.
Lewis 14 ...	16 38	45 22	119·1	19·96	2	9·0 11·0	·700	W.B.
Σ 2091 ...	16 39	48 38	306·3	1·07	2	7·5 8·0	·526	W.B.
			306·3	0·90	1	...	·616	L.
Σ 2094 AB	16 40	66 19	76·9	1·40	3	7·3 7·6	·521	W.B.
			83·7	1·37	1	...	·685	H.F.
AC	...		312·3	25·02	1	...	·685	H.F.
De 15 ...	16 41	46 21	276·8	0·43	1	8·1 8·6	·616	L.
			279·1	0·38	1	...	·700	W.B.
Espin 76 ...	16 42	39 13	45·2	2·64	1	9·0 9·5	·764	H.F.
Σ 2097 ...	16 42	54 6	82·7	2·08	2	8·5 8·7	·526	W.B.
			80·6	2·04	2	...	·723	H.F.
Σ 2101 ...	16 43	54 12	56·9	4·30	2	6·3 9·0	·723	H.F.
Weisse 31 AC	16 44	64 12	137·3	4·89	2	8·7 8·7	·600	H.F.
			245·6	26·59	1	11·0	·685	H.F.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch.	Obs.
	h m	° ′	°	″			1911	
Küstner 55	16 44	75 1	45·8	2·57	1	9·5 10·1	·685	H.F.
Σ 2106 ...	16 47	80 26	280·0	0·22	2	6·7 8·4	·411	B.
Σ 2107 ...	16 48	61 11	8·9	0·44	2	6·5 8·0	·411	B.
			18·4	0·62	1	...	·693	L.
β 821 ..	16 48	58 0	311·7	1·24	1	8·4 8·9	·685	H.F.
Aitken 350	16 50	60 45	138·3	0·43	2	9·0 9·0	·411	B.
			148·0	0·42	1	...	·693	L.
*	16 52	60 28	143·8	3·70	1	10·5 11·5	·693	L.
Σ 2109 ...	16 50	68 41	313·5	5·70	1	7·0 10·2	·515	H.F.
OΣ 319 ...	16 54	74 43	64·9	0·79	3	7·5 8·5	·461	W.B.
OΣ 320 ...	16 55	64 33	248·2	5·71	1	7·5 11·1	·685	H.F.
Σ 2118 ...	16 56	24 50	85·5	0·38	2	6·4 6·9	·478	B.
OΣ 322 ...	16 57	52 57	198·3	1·56	2	7·0 9·8	·529	W.B.
Σ 2114 ...	16 58	81 26	165·1	1·13	2	6·2 7·4	·475	W.B.
			168·8	1·28	1	...	·539	L.
Σ 2120 ...	17 1	61 48	240·4	9·34	2	6·4 9·2	·608	W.B.
Σ 2130 ...	17 3	35 24	139·2	2·38	1	5·0 5·1	·682	S.C.
Hussey 1176	17 5	53 57	139·4	0·12	4	6·0 6·0	·588	B.
β 1118 ...	17 5	105 36	245·4	0·37	2	3·4 3·9	·545	B.
Σ 2135 ...	17 8	68 40	180·7	7·30	1	7·1 8·4	·515	H.F.
			179·6	7·10	4	...	·567	W.B.
			179·7	6·97	1	...	·682	S.C.
Σ 2137 ...	...		142·0	3·95	2	...	·608	W.B.
Σ 2140 ...	17 11	75 30	116·2	4·97	1	3·0 6·1	·515	H.F.
			112·4	4·66	2	...	·608	W.B.
			114·6	4·65	2	...	·794	B.
Hussey 489	17 12	69 47	50·5	0·85	3	9·2 10·5	·497	W.B.
OΣ 327 .	17 12	33 46	147·4	0·35	2	7·6 7·9	·660	B.
Lewis 15 ...	17 15	57 25	298·8	3·09	1	10·0 11·0	·693	L.
β 46 ...	17 20	76 31	202·2	2·04	3	7·7 10·9	·497	W.B.
Hussey 1179	17 21	51 21	269·6	0·24	4	7·0 7·1	·588	B.
Σ 2177. ...	17 25	43 31	133·2	3·29	2	8·5 10·0	·670	W.B.
Σ 2173 ...	17 26	91 0	211·3	0·19	3	6·0 6·3	·532	B.
Σ 2182 ...	17 29	66 4	360·6	4·99	2	8·2 9·2	·610	W.B.
β 631 ...	17 35	90 36	56·1	0·34	2	7·0 7·0	·517	B.
Σ 2196 ...	17 38	68 46	257·5	3·39	2	9·2 11·2	·670	W.B.
Σ 2193 ...	17 38	81 44	246·7	5·83	1	9·9 9·9	·600	W.B.
Σ 2203 ...	17 38	48 18	316·6	0·55	3	7·5 7·8	·684	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Hough 560	17 40	56 1	94·9	0·80	1	8·0	8·0	·684	S.C.
Σ 2205 ...	17 42	72 15	309·5	1·95	2	8·3	8·7	·612	W.B.
			308·8	1·81	1	...		·832	B.
Σ 2215 ...	17 43	72 17	288·2	0·62	2	5·9	7·9	·475	W.B.
β 824 ...	17 44	91 51	355·7	0·71	2	8·5	8·6	·517	B.
Hussey 1182	17 45	54 22	7·7	0·70	1	8·7	9·1	·684	S.C.
OΣ 337 ...	17 46	82 45	266·9	0·35	2	7·5	8·0	·510	B.
Σ 2238 ...	17 47	52 14	286·6	1·97	2	9·2	9·7	·574	W.B.
OΣ 338 ...	17 48	74 40	14·0	0·79	2	6·6	6·9	·517	B.
			9·9	0·56	3	...		·497	W.B.
			13·7	0·95	1	...		·556	S.C.
Aitken 234	17 49	64 23	32·2	0·45	2	8·8	9·1	·517	B.
AC 8 ...	17 49	60 19	244·4	0·37	2	8·2	8·2	·517	B.
Aitken 235	17 50	65 0	263·1	0·37	2	7·9	8·1	·517	B.
AC 9 ...	17 51	60 10	237·7	1·19	2	8·3	8·8	·527	S.E.
			234·0	1·00	3	...		·697	W.B.
			234·8	1·19	1	...		·832	B.
OΣ 339 ...	17 52	68 29	177·5	3·46	2	7·5	9·9	·677	W.B.
β 417 ...	17 53	50 33	277·4	1·42	2	8·1	10·0	·797	W.B.
β 1299 ...	17 53	79 2	150·7	0·44	1	8·5	8·5	·564	B.
Σ 2255 ...	17 54	48 44	341·8	8·96	1	8·5	10·5	·684	S.C.
Σ 2267 ...	17 59	49 49	245·8	0·98	1	8·0	8·0	·578	L.
			244·7	1·28	1	...		·684	S.C.
Hough 77 ...	17 59	49 40	306·8	2·05	1	7·9	12·0	·578	L.
β 1127 ...	18 0	45 46	133·2	0·87	1	7·8	9·7	·791	W.B.
Hough 565	18 0	63 56	68·7	0·40	2	8·3	8·3	·517	B.
Σ 2275 ...	18 0	50 39	136·3	0·87	1	9·0	9·2	·564	B.
			132·2	0·62	1	...		·578	L.
Lewis 19 ...	18 1	50 37	267·8	0·36	1	9·0	9·2	·693	L.
Σ 2272 ...	18 1	87 27	148·3	3·55	13	4·5	6·0	·531	W.B.
OΣ 534 ...	18 1	68 34	278·7	2·19	1	7·5	9·5	·832	B.
			279·1	2·63	1	...		·556	S.C.
OΣ 341 ...	18 2	68 34	94·3	0·44	1	6·4	7·7	·509	S.E.
			90·4	0·38	2	..		·545	B.
OΣ 524 ...	18 4	70 21	56·5	0·29	1	7·0	8·3	·564	B.
Σ 2281 ...	18 5	86 2	264·4	0·21	2	5·7	7·2	·545	B.
Σ 2283 ...	18 5	83 52	82·8	0·84	2	7·2	7·7	·545	B.
Σ 2285 ...	18 5	76 32	333·6	3·28	2	8·2	10·0	·535	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Hussey 314	18 5	71 23	142·5	0·44	3	8·3	8·5	·560	W.B.
Σ 2289 ...	18 6	73 33	227·7	1·13	2	6·0	7·1	·544	S.C.
			228·8	1·30	1	...		·545	S.E.
			229·0	1·13	2	...		·622	W.B.
			226·2	1·04	1	...		·832	B.
Hussey 316	18 6	71 45	154·2	1·60	3	9·0	10·1	·662	W.B.
Hussey 674	18 7	39 37	273·6	0·37	1	7·5	8·0	·791	W.B.
Hussey 317	18 7	72 48	19·6	1·65	2	8·5	8·8	·623	W.B.
Aitken 238	18 8	64 42	94·2	0·54	3	8·5	9·5	·560	W.B.
Σ 2292 ...	18 9	62 23	267·3	1·07	1	8·0	8·1	·526	W.B.
			266·4	1·25	2	...		·527	S.E.
			267·8	1·27	2	...		·711	S.C.
Σ 2294 ...	18 10	89 51	281·9	0·38	2	7·4	7·7	·545	B.
β 1091 ..	18 10	51 26	23·7	0·43	1	8·6	8·6	·832	B.
AG 221 ...	18 16	68 42	187·8	1·68	1	9·0	9·4	·772	S.C.
			188·5	1·14	2	...		·777	W.B.
Hough 430	18 18	69 32	196·6	2·74	1	8·5	9·0	·682	S.C.
			193·9	2·29	2			·775	W.B.
*	18 18	69 32	138·3	9·16	2	8·5	9·8	·775	W.B.
Lewis 21 ...	18 18	69 25	104·8	6·34	1	10·0	11·0	·712	L.
Lewis 20 ...	18 18	69 30	336·3	1·73	2	7·5	9·0	·775	W.B.
Hough 83 ...	18 20	62 32	88·2	0·46	2	8·7	8·7	·538	W.B.
			279·4	0·78	1			·712	L.
β 1203 ...	18 21	89 16	78·0	0·27	2	7·5	7·7	·545	B.
Σ 2315 ...	18 21	62 39	183·7	0·26	3	7·0	8·0	·560	W.B.
			193 2	0·38	1	...		·712	L.
* ...	18 21	62 40	318·8	3·56	1	9·5	10·0	·712	L.
Lewis 24 ...	18 23	64 1	272·8	3·36	1	9·5	10·0	·712	L.
β 134 ...	18 23	43 10	135·1	1·11	2	7·9	9·8	·796	W.B.
Hussey 245	18 29	78 17	53·1	2·05	3	8·2	9·2	·623	W.B.
OΣ 358 ...	18 32	73 6	192·2	2·12	2	6·8	7·2	·589	S.C.
OΣ 357 ...	18 32	78 21	241·7	0·37	2	7·5	7·6	·545	B.
			237·2	0·28	3	...		·612	W.B.
OΣ 359 ...	18 32	66 28	332·3	0·28	4	6·6	6·9	·560	W.B.
Hough 87 ...	18 35	73 32	288·0	0·32	2	8·0	8·0	·545	B.
Σ 2356 ...	18 35	61 23	50·8	0·83	1	8·0	9·0	·545	S.E.
			58·1	1·10	3	...		·561	W.B.
			54·9	1·08	1	..		·685	H.F.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch. 1911	Obs.
Σ 2364 ...	18 36	65 22	177·7	7·95	2	8·0 10·2	·775	W.B.
Hussey 1190	18 37	51 58	170·1	1·72	1	9·5 9·5	·685	H.F.
Σ 2392 AB	18 42	50 52	317·1	3·06	1	8·2 10·2	·685	H.F.
AC	...		176·3	23·46	1	9·3	·685	H.F.
Hussey 755	18 43	38 5	120·7	0·68	1	8 7 9·0	·684	S.C.
Hussey 936	18 45	56 5	103·4	1·78	1	8·8 9·1	·685	H.F.
β 265 ...	18 46	78 35	229·6	1·37	3	7·1 9·1	·547	W.B.
			229·0	1·27	1	...	·723	H.F.
Σ 2408 ...	18 48	79 20	93·1	1·84	1	7·5 8·7	·723	H.F.
β 421 ...	18 49	46 43	297·0	0·93	3	9·1 9·3	·790	W.B.
Σ 2415 ...	18 51	69 30	293·6	1·90	2	6·6 8·5	·545	W.B.
			292·1	1·81	1	...	·723	H.F.
β 137 ...	18 51	52 44	136·9	1·12	2	8·2 8·7	·785	W.B.
			130·4	1·45	1	...	·772	S.C.
Σ 2422 ...	18 53	64 2	93·3	0·75	2	7·6 7·7	·527	S.E.
			92·3	0·96	2	...	·552	W.B.
Aitken 260	18 54	57 58	244·3	0·82	2	8·9 9·1	·785	W.B.
Hussey 330	18 55	70 32	29·8	0·85	3	9·0 9·3	·569	W.B.
β 649 ...	18 56	57 40	14·1	1·62	1	8·5 11·7	·712	L.
Σ 2437 ...	18 58	70 58	55·7	0·86	1	7·8 8·0	·723	H.F.
β 466 ...	19 1	79 18	163·3	1·74	2	9·2 10·0	·568	W.B.
			166·2	1·86	1	...	·723	H.F.
Bird 4 ...	19 1	57 22	308·4	2·64	1	8·4 8·6	·772	S.C.
Σ 2454 ...	19 3	59 42	253·6	0·88	3	8·0 9·2	·697	W.B.
Σ 2466 ...	19 4	60 20	106·7	2·28	2	8·0 8·5	·642	W.B.
			275·1	2·42	1	...	·772	S.C.
Hough 442	19 5	70 55	95·2	3·76	3	9·3 10·3	·564	W.B.
Σ 2481 ...	19 8	51 22	218·2	4·24	2	8·0 8·0	·785	W.B.
			219·4	4·30	2	...	·711	S.C.
Secchi 2 ...	19 8	51 22	112·6	0·30	1	8·5 8·5	·791	W.B.
β 139 ...	19 9	73 18	140·4	0·73	1	6·7 8·0	·723	H.F.
Σ 2482 ...	19 9	71 1	343·8	1·92	2	8·5 9·2	·556	W.B.
			348·6	1·80	1	...	·723	H.F.
OΣ 368 ...	19 12	74 0	214·7	0·83	2	7·3 8·5	·622	W.B.
			214·6	0·95	1	...	·723	H.F.
			212·3	1·14	1	...	·682	S.C.
Σ 2491 ...	19 13	61 53	218·5	1·12	3	7·9 9·2	·697	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
Hussey 336	19 13	71 17	197·0	1·32	3	8·9	9·2	·623	W.B.
			200·0	1·40	1	..		·723	H.F.
β 1129 ...	19 20	37 48	331·6	0·31	1	6·3	6·3	·775	B.
Σ 2513 ...	19 21	87 44	317·6	1·99	2	8·2	8·8	·556	W.B.
Espin 80 ...	19 21	57 2	189·5	3·36	2	8·6	9·0	·642	W.B.
			191·8	4·25	1	...		·649	S.C.
Σ 2520 ...	19 23	77 19	235·2	1·79	2	8·8	9·3	·546	W.B.
Σ 2524 ...	19 23	64 42	96·3	6·50	2	8·3	8·5	·527	S.E.
			96·4	6·84	1	...		·772	S.C.
Σ 2525 ...	19 23	62 52	304·5	0·75	3	7·5	7·9	·561	W.B.
Σ 2527 ...	19 23	69 30	20·3	4·30	1	8·2	9·7	·723	H.F.
Hough 450	19 23	51 22	264·1	0·93	1	8·0	8·7	·682	S.C.
AB	...		269·3	0·94	2		12·1	·797	W.B.
Hussey 340	19 24	71 42	123·7	0·86	1	9·0	9·3	·723	H.F.
AG 231 ...	19 25	72 13	240·6	4·26	1	9·2	9·5	·723	H.F.
β 143 ...	19 27	40 41	191·3	2·08	2	8·0	9·1	·797	W.B.
Σ 2540 ...	19 29	69 47	144·2	4·94	1	7·5	9·0	·723	H.F.
Aitken 713	19 29	42 43	215·8	0·25	1	6·9	7·3	·791	W.B.
OΣ 375 ...	19 31	72 4	147·9	0·59	3	7·2	8·4	·569	W.B.
Hough 110	19 35	71 31	77·8 78·1	2·53 2·41	2 1	9·3	9·3	·682 ·723	W.B. H.F.
Σ 2556 ...	19 36	67 57	127·4	0·31	2	7·3	7·3	·626	W.B.
			128·8	0·36	2	...		·679	B.
OΣ 380 ...	19 38	78 23	82·1	0·54	1	6·0	7·2	·509	S.E.
			76·2	0·45	2	...		·682	W.B.
			77·2	0·45	1	...		·775	B.
OΣ 382 ...	19 38	62 50	352·3	0·42	1	7·1	7·6	·775	B.
β 1132 ...	19 39	63 17	272·2	0·15	1	8·3	8·7	·775	B.
β 658 ...	19 40	63 5	289·0	0·46	1	6·5	10·0	·775	B.
Σ 2577 ...	19 41	69 19	261·3	5·73	1	8·1	9·5	·723	H.F.
			264·1	6·03	1	...		·646	S.C.
Σ 2569 ...	19 41	73 24	1·5	2·38	1	8·0	8·5	·723	H.F.
Dawes 13 ...	19 42	45 18	267·5	1·86	2	7·5	11·3	·797	W.B.
Σ 2576 ...	19 42	56 36	105·3	2·07	2	7·8	7·8	·797	W.B.
			104·5	2·29	1	...		·772	S.C.
Σ 2583 ...	19 44	78 25	114·5	1·45	2	6·0	6·7	·588	W.B.
OΣ 387 ...	19 45	54 56	317·9	0·45	2	7·2	8·2	·797	W.B.
β 361 ...	19 46	67 34	351·1	3·74	1	9·2	9·9	·723	H.F.
Σ 2588 ...	19 46	45 51	157·1	9·83	1	7·9	8·3	·772	S.C.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
β 978 ...	19 48	66 43	237·3	1·11	1	8·3	8·4	·527	S.E.
			240·3	0·87	3	...		·649	W.B.
			232·4	1·04	1	...		·723	H.F.
OΣ 388 ...	19 49	64 22	138·8	3·40	1	7·6	7·6	·723	H.F.
			136·5	3·69	1	...		·772	S.C.
Σ 2596 ...	19 50	74 56	323·9	1·90	3	7·2	8·6	·649	W.B
Hough 581	19 52	48 23	122·1	0·28	1	7·5	7·5	·775	B.
β 425 ...	19 54	69 57	60·0	1·39	2	8·2	9·0	·588	W.B.
OΣ 395 ...	19 58	65 19	106·3	0·61	3	5·8	6·2	·655	B.
Aitken 1194	20 0	77 54	300·8	0·77	3	8·9	9·0	·600	W.B
β 428 ...	20 2	77 19	355·5	0·78	1	7·2	8·5	·509	S.E.
			351·0	0·76	3	...		·613	W.B.
Σ 2644 ...	20 8	89 24	209·2	3·52	1	7·1	7·4	·649	S.C.
Σ 2653 ...	20 10	66 3	263·4	2·40	2	7·0	10·1	·545	W.B.
OΣ 403 ...	20 11	48 11	171·6	0·91	1	7·0	7·2	·682	S.C.
Σ 2657 R ...	20 11	48 11	36·0	10·93	1	7·0	9·5	·682	S.C.
β 984 ...	20 14	63 55	215·6	0·81	2	7·9	8·2	·545	W.B.
Σ 2672 ...	20 18	66 31	295·0	0·93	3	8·7	8·8	·547	W.B.
β 432 ...	20 21	54 31	199·2	1·41	1	8·6	9·9	·646	SC.
Aitken 393	20 23	62 14	213·3	0·34	3	8·7	9·2	·686	W.B.
Σ 2690 ...	20 27	79 3	256·9	15·90	1	7·0	7·2	·797	S.C.
Σ 2695 ...	20 28	64 30	77·1	1·08	2	6·8	8·0	·545	W.B.
			81·8	0·98	1	...		·761	H.F.
Lewis 35 ...	20 28	76 22	115·9	0·39	3	9·0	9·5	·686	W.B.
β 670 ...	20 29	76 22	37·6	0·42	4	8·5	8·8	·672	W.B.
Σ 2698 ...	20 30	62 6	302·5	4·06	2	8·1	9·0	·570	W.B.
			302·9	4·24	1	...		·761	H.F.
AG 258 ...	20 32	79 52	10·6	4·04	2	9·2	9·4	·570	W.B.
β 151 ...	20 33	75 43	196·8	0·30	1	4·5	6·0	627	W.B.
			205·3	0·17	2	...		·794	B.
Aitken 742	20 34	60 36	129·2	1·05	1	9·5	10·0	·761	H.F.
Aitken 744	20 34	60 26	269·8	0·75	1	8·8	8·8	·761	H.F.
AG 261 ...	20 34	59 11	153·9	4·00	2	9·0	9·5	·849	H.F.
β 435 ...	20 35	75 19	115·6	2·82	3	8·1	10·9	·547	W.B.
OΣ 410 ...	20 36	49 45	17·8	0·68	2	6·4	6·7	·794	B.
Σ 2716 ...	20 37	58 1	48·6	2·94	1	6·0	8·2	·936	H.F.
			48·7	2·74	2	...		·722	S.C.
β 64 ...	20 41	77 37	192·3	0·28	1	8·7	9·0	·627	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
AG 264 ...	20 42	65 38	356·7	1·78	2	9·0	9·1	·565	W.B.
			353·3	2·12	1	...		·761	H.F.
β 65 ...	20 43	84 19	188·1	1·16	1	5·2	8·8	·821	H.F.
β 364 ...	20 43	64 55	47·1	1·25	2	8·7	8·9	·545	W.B.
			46·3	1·33	1	...		·761	H.F.
β 66 ...	20 44	62 52	159·9	1·23	2	8·6	9·1	·568	W.B.
			157·4	1·32	1	...		·761	H.F.
OΣ 413 ...	20 44	53 50	54·4	0·72	2	5·0	6·3	·794	B.
AG 267 ...	20 44	85 53	261·4	2·41	1	9·0	9·2	·821	H.F.
β 366 ...	20 46	39 50	130·7	1·68	1	8·2	8·5	·684	S.C.
β 67 ...	20 47	59 25	289·4	1·74	1	6·9	10·2	·761	H.F.
Aitken 1212	20 48	80 6	21·3	0·66	1	8·6	9·1	·821	H.F.
Lewis ...	20 49	61 0	148·6	3·58	1	9·5	10·5	·802	W.B.
*	20 49	60 59	352·4	9·79	1	8·0	10·5	·802	W.B.
OΣ 417 ...	20 49	61 11	26·6	0·65	2	7·5	8·1	·771	W.B.
			29·2	0·78	1	...		·761	H.F.
OΣ 418 ...	20 51	57 38	288·3	1·18	1	7·3	7·4	·545	S.E.
			292·7	1·25	1	...		·646	S.C.
			288·9	1·17	1	...		·761	H.F.
			290·5	1·16	2	...		·771	W.B.
β 367 ...	20 51	62 15	164·9	0·24	1	7·5	7·9	·813	B.
Hussey 363	20 55	71 58	95·0	0·54	1	9·3	9·3	·627	W.B.
Σ 2737 ...	20 55	86 3	274·8	0·35	2	5·7	6·2	·794	B.
Aitken 176	20 57	69 24	134·0	0·32	1	9·2	9·3	·586	W.B.
β 69 ...	20 59	68 40	312·7	0·87	2	8·2	9·0	·565	W.B.
			312·3	1·04	1	...		·821	H.F.
Σ 2749 ...	21 0	86 50	158·9	2·40	1	7·7	8·9	·813	B.
Secchi 3 ...	21 0	86 50	158·7	0·92	1	8·9	8·9	·813	B.
Aitken 178	21 2	69 4	76·4	0·81	2	8·1	9·3	·549	W.B.
			60·5	1·07	1	...		·821	H.F.
OΣ 430 ...	21 8	66 31	204·1	1·41	2	7·8	9·8	·549	W.B.
Hough 152	21 9	62 2	330·0	0·39	3	8·2	8·3	·598	W.B.
Hussey 767	21 10	74 24	148·3	0·24	1	7·0	7·0	·775	B.
OΣ 535 ...	21 10	80 22	360·3	0·21	3	4·5	5·0	·623	W.B.
			7·9	0·15	2	...		·794	B.
OΣ 432 ...	21 11	49 14	124·4	1·22	2	6·8	7·2	·797	W.B.
			125·4	1·50	2	...		·741	S.C.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
β 1261 ...	21 12	74 17	149·5	1·34	3	8·5	9·7	·587	W.B.
			146·8	1·68	1	...		·821	H.F.
β 162 ...	21 13	54 37	244·4	1·13	1	8·0	8·5	·791	W.B.
Hough 153	21 14	56 37	125·9	0·99	1	8·0	9·0	·791	W.B.
Hough 286	21 16	52 8	314·4	0·22	2	6·0	6·0	·794	B.
β 838 ...	21 16	87 15	109·4	1·51	1	7·6	9·5	·739	W.B.
			104·9	1·66	1	...		·813	B.
Aitken 295	21 17	62 39	232·0	0·36	2	8·5	8·7	·657	W.B.
OΣ 437 ...	21 17	57 55	38·7	1·82	2	6·5	7·2	·765	W.B.
			40 3	2·01	2	...		·741	S.C.
Aitken 617	21 17	80 2	285·0	0·22	2	7·0	7·0	·794	B.
Σ 2791 ...	21 19	86 1	102·0	2·32	3	8·5	9·0	·675	W.B.
β 164 ...	21 21	81 0	238·5	0·49	3	7·5	8·0	·597	W.B.
Σ 2799 ...	21 24	79 18	291·9	1·45	2	6·6	6·6	·569	W.B.
			290·5	1·42	1	...		·821	H.F.
Holden 45	21 27	55 20	192·8	1·22	2	8·5	9·1	·860	W.B.
Hussey 371	21 31	65 57	157·8	0·18	4	7·0	7·5	·653	W.B.
			157·8	0·21	2	...		·794	B.
β 1212 ...	21 35	90 28	282·5	0·44	2	6·5	6·9	·794	B.
Hough 164	21 37	55 20	244·0	3·27	1	8·3	8·4	·928	W.B.
OΣ 448 ...	21 37	61 4	226·9	0·76	3	7·7	8·7	·787	W.B.
Hough 165	21 38	71 25	65·2	0·45	2	8·0	8·4	·583	W.B.
β 274 ...	21 38	71 25	180·7	3·15	1	7·8	10·9	·928	W.B.
Hough 166	21 40	62 34	64·8	0·30	3	7·5	7·5	·633	W.B.
Σ 2822 ...	21 40	61 40	126·8	1·73	2	4·0	5·0	·637	W.B.
			131·3	2·15	1	...		·797	S.C.
β 989 ...	21 41	64 46	269·8	0·24	3	4·3	5·0	·623	W.B.
			283·5	0·23	2	...		·794	B.
AG 276 ...	21 41	68 29	356·5	1·86	2	8·8	9·2	·569	W.B.
Hough 168	21 42	46 29	236·8	0·93	1	8·4	8·5	·928	W.B.
AG 277 ...	21 42	69 14	234·4	2·31	2	9·0	9·0	·785	W.B.
Hough 171	21 48	62 38	179·1	0·81	1	8·1	8·2	·797	S.C.
			173·3	0·71	2	..		·618	W.B.
β 75 ...	21 51	79 33	47·1	0·78	2	8·1	8·5	·605	W.B.
			41·9	0·99	3	...		·807	B.
OΣ 452 ...	21 51	53 11	174·2	0·91	3	7·7	8·8	·695	W.B.
AG 278 ...	21 52	57 24	157·4	3·20	1	9·5	9·5	·928	W.B.
Σ 2849 ...	21 53	70 11	259·9	1·37	1	8·2	10·7	·830	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch.	Obs.
	h m	° ′	°	″				1911	
β 696 ...	22 0	74 34	349·4	0·43	2	8·0	8·0	·794	B.
OΣ 464 ...	22 7	50 16	66·6	0·72	1	7·8	8·0	·797	S.C.
Σ 2881 ...	22 10	60 52	99·6	1·86	2	7·7	8·2	·787	S.C.
			103·8	1·37	1	...		·928	W.B.
AG 281 ...	22 11	68 30	21·2	2·39	4	8·8	9·8	·631	W.B.
Hough 180	22 12	46 33	231·1	0·71	1	7·3	7·8	·928	W.B.
β 1216 ...	22 16	60 56	303·1	0·61	2	8·4	8·7	·794	B.
			309·5	0·80	1	...		·928	S.C.
β 172 ...	22 19	95 18	350·6	0·75	2	6·7	6·7	·794	B.
Σ 2900 ...	22 19	69 36	174·7	1·34	3	6·0	9·2	·634	W.B.
β 291 ...	22 23	85 56	167·4	0·33	1	8·4	8·4	·813	B.
Σ 2909 ...	22 24	90 29	309·8	3·05	1	4·0	4·1	·928	S.C.
β 1218 ...	22 24	60 46	54·4	1·79	1	8·6	8·8	·928	S.C.
Σ 2912 ...	22 25	86 2	112·3	0·31	1	5·8	7·2	·813	B.
Hough 475 AB	22 29	64 3	315·4	0·81	2	...		·626	W.B.
AC	...		222·5	8·34	2	8·5	8·7	·626	W.B.
β 710 ...	22 38	60 46	239·0	0·44	2	8·5	8·6	·823	B.
Σ 2934 ...	22 38	69 3	126·5	0·86	2	8·2	9·2	·626	W.B.
β 382 AB ...	22 50	45 43	236·6	0·91	1	6·0	8·0	·928	S.C.
AC	...		354·9	26·97	1	...	10·7	·928	S.C.
Σ 2957 ...	22 52	73 1	225·6	4·41	2	8·6	10·4	·692	W.B.
OΣ 483 ...	22 55	78 45	232·4	0·87	3	6·2	7·7	·742	W.B.
			228·7	1·30	1	...		·928	S.C.
Holden 56...	22 56	48 39	117·9	1·10	1	8·4	8·5	·928	S.C.
HG 289 ...	22 59	67 19	48·0	1·73	3	9·2	9·2	·742	W.B.
Hough 193	22 59	60 5	166·8	2·52	2	7·3	10·5	·747	W.B.
Σ 2989 ...	23 9	70 30	140·8	1·54	2	8·5	9·9	·699	W.B.
Σ 2990 ...	23 9	68 25	60·6	2·03	2	8·0	8·1	·782	W.B.
			59·9	2·51	1	...		·928	S.C.
β 80 ...	23 14	85 5	226·2	0·35	2	8·2	9·1	·823	B.
Σ 3002 ...	23 16	88 2	198·1	3·76	1	8·0	10·2	·846	W.B.
Σ 3008 ...	23 19	28 58	228·8	4·05	1	7·0	8·0	·928	S.C.
Σ 3020 ...	23 27	71 43	105·4	2·20	2	7·7	9·7	·838	W.B.
Σ 3033 ...	23 39	83 15	4·4	2·96	2	8·5	8·5	·857	W.B.
Σ 3050 ...	23 55	56 46	222·9	2·47	1	6·0	6·0	·928	S.C.

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Note on a New Similarity between the Variations of S Persei and of Sunspots. By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. In former papers (*e.g. Mon. Not.*, lxvii. p. 332) a comparison has been made of the sunspot curve with the light curves of long-period variables, chiefly in respect of the harmonic terms in the variation which are one-half and one-third of the main period, which in the case of the Sun was adopted as $11\frac{1}{8}$ years. But in February 1906 Professor A. Schuster pointed out (*Phil. Trans.*, vol. 206, A, p. 69) that in the case of sunspots other periodicities are associated with this well-known "eleven-year" period, and that these other periods seemed to be submultiples of a master period of $33\frac{3}{8}$ years; viz. the $\frac{1}{7}$ (about 4·77 years), the $\frac{1}{4}$ (about 8·17 years), the $\frac{1}{3}$ (the well-known 11·13 years), and perhaps the $\frac{2}{5}$ (13·35 years).

2. It had not occurred to me until a few days ago to examine the cases of the variable stars for a similar association of periodicities; but such a suggestion arose in the course of other work, and I proceeded to examine the Rousdon observations (*Mem. R.A.S.*, vol. lv.). Promising results were forthcoming almost immediately, but my attention was especially arrested by the case of S Persei. The following extract from the above memoir (p. lxxi) will show that a close analogy to the Sun had already presented itself some two years before the publication of Professor Schuster's paper, though it had quite escaped my memory:—

"It almost seems as though we must admit three independent waves of periods 840, 1120, and 3360 days approximately; and semi-amplitudes 0·6, 0·4, and 0·4 magnitude."

Adopting this supposition, it is shown in the memoir that both the Rousdon and Harvard observations can be well represented.

3. The relation of these three periods to the 8·17 year, 11·13 year, and 33·38 year sunspot periods is rendered more conspicuous by a chance similarity in figures. The need for caution in the statement was due to the fact that the longest period named occupied practically the whole extent of the observations then available, and the others were only run through three and four times. But the Rousdon observations have been continued, and were put into my hands recently for editing. They are nearly ready for press, and it was easy to examine the additional material to see whether the conjectures of 1904 were confirmed. It will be seen that satisfactory confirmation is thus afforded.

4. We will first give the material in the shape adopted on p. lxx of the Rousdon observations (*Mem. R.A.S.*, vol. lv.). The individual observations have been compared with a smooth curve, drawn on a large scale through the twelve points given in the lowest line "Mag. from Curve." The differences are read off to 0·1 magnitude, and the means formed of portions extending ± 35 days on each side of the standard twelve points. The curve was

drawn to suit the former observations (first four rows), and has not been readjusted in any way: it is not, therefore, surprising to find that it does not fit the new observations (last four rows) equally well. There seems to have been either some systematic change in the observer, or a long-period change in the star, for the sums of the eight rows are $-5, +9, +6, -3, +7, +49, +56, +44$. At present, scrutiny has failed to suggest any observational reason for the change in the last three periods, which is approximately 36 units of 0·1 magnitude in the sum of twelve residuals, or 0·3 systematically.

TABLE I.

S Persei. Assumed period 840 *days. Residuals* (*unit* 0·1 *mag.*) *for each group of* 70 *days.* (*Bracketed residuals have been interpolated.*)

Jul. Date 2400000+.	0.	70.	140.	210.	280.	350.	420.	490.	560.	630.	700.	770.
1952	−3	− 1	− 3	−6	−4	−1	+1	+1	+2	+2	+5	+ 2
2792	+3	+ 3	+ 2	0	0	0	−1	0	−3	−1	+1	+ 5
3632	+6	+ 4	+ 5	+5	+7	+3	−2	−3	−1	−2	−5	−11
4472	−4	+ 1	0	+4	−3	−3	+2	+4	0	−2	−2	0
5312	−3	− 9	− 8	−9	−2	+5	+4	+8	+9	+7	+3	+ 2
6152	+4	+ 1	− 1	+3	+5	+6	+8	+7	+5	+6	+2	+ 3
6992	+8	+12	+11	(+8)	+5	+2	+4	+2	−3	+2	+4	+ 1
7832	+9	+11	(+ 7)	+3	−3	−3	+1	(0)	−1	−1	+8	+13
Mag. from curve.	8·65	8·54	8·57	8·67	8·87	9·13	9·37	9·58	9·73	9·70	9·45	9·03

5. *Main period of* 840 *days.*—The first harmonic for the adopted curve is found to be

$$-0\cdot51 \sin\theta - 0\cdot32 \cos\theta = 0\cdot64 \cos(\theta - 238^\circ).$$

Taking the means of the old observations in the first four rows, and of the new observations in the last four, we get for the first harmonics:

$$\text{Old residuals } +0\cdot07 \sin\theta + 0\cdot03 \cos\theta$$
$$\text{New residuals } -0\cdot07 \sin\theta + 0\cdot05 \cos\theta,$$

and adding these to the mean curve we get:

$$\text{Old observations } -0\cdot44 \sin\theta - 0\cdot29 \cos\theta = 0\cdot53 \cos(\theta - 237^\circ).$$
$$\text{New observations } -0\cdot58 \sin\theta - 0\cdot27 \cos\theta = 0\cdot64 \cos(\theta - 245^\circ).$$

The advance of phase is very slight, only 8° in four periods, so that we may regard the main period as satisfactorily adopted, though it may be (say) 845 days.

6. *Period of* 1120 *days.*—This was indicated in the memoir cited by adding consecutive terms and arranging in eight groups. The

old observations thus yield exactly three periods and so do the new, and the first harmonics are found to be:

Old observations $-0{\cdot}20 \sin\theta - 0{\cdot}26 \cos\theta = 0{\cdot}33 \cos(\theta - 217^\circ)$.
New observations $+0{\cdot}03 \sin\theta - 0{\cdot}20 \cos\theta = 0{\cdot}20 \cos(\theta - 172^\circ)$.

The change of phase is in the opposite direction to that just found: but it is small,—only 45° in three whole periods. The coefficients of sin θ and cos θ are much smaller, and accidental errors might easily account for the discordance: but if it is real, it indicates a period of $1120(1 - 45/1080)$ days $= 1073$ days.

7. *Master period of* 3360 *days.*—The old observations and the new each give one whole period, and the first harmonics are:

Old observations $+0{\cdot}13 \sin\theta - 0{\cdot}12 \cos\theta = 0{\cdot}18 \cos(\theta - 132^\circ)$.
New observations $+0{\cdot}08 \sin\theta - 0{\cdot}27 \cos\theta = 0{\cdot}28 \cos(\theta - 163^\circ)$.

If the change of phase is real, the true period is $3360(1 + 31/360) = 3669$ days.

8. Is there a period of 3360/7 days, corresponding to the 4·77 years in sunspots? Our unit interval is 70 days: and seven of them make 490 days, whereas we are to examine a periodicity of 480 days. We can do it by analysing in periods of 7 units and noting the change of phase, if any. The harmonics are for the four groups of three periods each which the observations allow:

$$\begin{aligned}
&-0{\cdot}02 \sin\theta + 0{\cdot}06 \cos\theta = 0{\cdot}07 \cos(\theta - 341^\circ)\\
&+0{\cdot}04 \sin\theta - 0{\cdot}16 \cos\theta = 0{\cdot}17 \cos(\theta - 166)\\
&-0{\cdot}13 \sin\theta - 0{\cdot}01 \cos\theta = 0{\cdot}13 \cos(\theta - 265)\\
&-0{\cdot}02 \sin\theta - 0{\cdot}12 \cos\theta = 0{\cdot}12 \cos(\theta - 189)\\
\text{Mean}\quad &-0{\cdot}03 \sin\theta - 0{\cdot}06 \cos\theta = 0{\cdot}07 \cos(\theta - 240)
\end{aligned}$$

We have adopted a period of 490 days. If the true period is 480, the phase should diminish by $360/48 = 7\frac{1}{2}^\circ$ each period, or $22\frac{1}{2}^\circ$ in three periods. Hence, taking 240° as the mean phase, the calculated and observed phases are as follows:—

Calculated.	Observed.	O − C.
274°	341°	+68°
251	166	−85
228	265	+37
206	189	−17

While the coefficient is too small to be certain of, the evidence is consistent with the existence of a small periodicity of this kind.

9. Is there also a period of $\frac{2}{5}$ of 3360 days $= 1344$ days corresponding to the 13·5-year period in sunspots? $1344/70 = 19{\cdot}2$: we can get five consecutive periods. Analysis gives for a period of nineteen terms exactly (mean of five periods)

$$+{\cdot}05 \sin\theta - {\cdot}01 \cos\theta,$$

which is too small to be further noticed. But if we form the *second* harmonic of the same series, we get:

$$\begin{aligned}
&-0{\cdot}11 \sin 2\theta + 0{\cdot}06 \cos 2\theta = 0{\cdot}12 \cos 2(\theta - 150^\circ)\\
&-0{\cdot}09 \sin 2\theta + 0{\cdot}03 \cos 2\theta = 0{\cdot}10 \cos 2(\theta - 144)\\
&-0{\cdot}40 \sin 2\theta - 0{\cdot}23 \cos 2\theta = 0{\cdot}46 \cos 2(\theta - 120)\\
&-0{\cdot}32 \sin 2\theta + 0{\cdot}00 \cos 2\theta = 0{\cdot}32 \cos 2(\theta - 135)\\
&-0{\cdot}42 \sin 2\theta + 0{\cdot}25 \cos 2\theta = 0{\cdot}48 \cos 2(\theta - 150)\\
\hline
\text{Mean } &-0{\cdot}26 \sin 2\theta + 0{\cdot}02 \cos 2\theta = 0{\cdot}26 \cos 2(\theta - 137)
\end{aligned}$$

This is a well-marked periodicity of 665 days (for the phase is sensibly constant), to which would correspond one of 6·68 years in sunspots. There is a slight elevation near this point in Professor Schuster's periodogram, but nothing very striking.

10. Let us now return to the sunspots and inquire whether the master period of 33·375 years is itself represented in the observations, as the corresponding period is in S Persei. There is no need to adopt this exact period in the analysis if we note the change of phase; and in the first instance 36 years was adopted for the convenience of arranging means of 3 consecutive years in sets of 12. The analysis gave for four consecutive periods of 36 years:

$$\begin{aligned}
&\text{I. } 18 \cos(\theta - 232^\circ) && 232^\circ - 0^\circ = 232^\circ = 230^\circ + 2^\circ\\
&\text{II. } 27 \cos(\theta - 25) && 25 - 170 = 215 = 230 - 15\\
&\text{III. } 22 \cos(\theta - 176) && 176 - 340 = 196 = 230 - 34\\
&\text{IV. } 16 \cos(\theta - 61) && 61 - 510 = 271 = 230 + 41
\end{aligned}$$

There is no need to dwell upon this stage, for it is clear from the advance of phase by approximately 170° that the dominant period is very different from that adopted. Its value is nearer

$$36(1 + 170/360) \text{ years} = 53 \text{ years}.$$

11. This does not mean as yet that there is no periodicity near 36 years, but that it is in any case overpowered by another. Let us therefore examine 54 years. Taking means of 6 consecutive years and arranging in series of 9, we get for the first harmonic, in 3 consecutive periods (1749–1910),

$$\begin{aligned}
&\text{I. } -1 \sin\theta - 20 \cos\theta = 20 \cos(\theta - 184^\circ).\\
&\text{II. } -21 \sin\theta - 15 \cos\theta = 26 \cos(\theta - 234).\\
&\text{III. } +8 \sin\theta + 9 \cos\theta = 12 \cos(\theta - 42).
\end{aligned}$$

Here again the adopted period, if represented at all, is dominated by another. The phase increases by about 90°, which would give us a period of

$$54(1 + 90/360) = 67{\cdot}5 \text{ years},$$

approximately double what we started with. Now there is no reason why all these periods should not exist: but if they do they

will mask one another, and to examine any one separately we must remove the others.

12. Let us continue by examining now 72 years (12 terms of 6 years each). We can only get two periods, and the first harmonics are

$$+20 \sin\theta - 14 \cos\theta = 25 \cos(\theta - 125^\circ)$$
$$+\ 9 \sin\theta - 11 \cos\theta = 14 \cos(\theta - 141^\circ).$$

If we may trust the change of phase, the true period is $72(1 + 16/360)$ years $= 75$ years. But it will suffice for our purpose to examine the effect of supposing a periodicity of this kind in an approximate form, and we will assume for convenience that the periodicity is 72 years and adopt the approximate mean value

$$+15 \sin\theta - 12 \cos\theta,$$

so that the nine terms of the postulated 54-year period would be affected as follows:—

−12	− 3	+ 7	+15	+19	+18	+12	+ 3	− 7
−15	−19	−18	−12	− 3	+ 7	+15	+19	+18
+12	+ 3	− 7	−15	−19	−18	−12	− 3	+ 7

and analysing these harmonically we get

$$\text{I.} \quad +\ 2 \sin\theta - 15 \cos\theta.$$
$$\text{II.} \quad -18 \sin\theta - \ 5 \cos\theta.$$
$$\text{III.} \quad -\ 2 \sin\theta + 15 \cos\theta.$$

13. If then we first remove such a term by applying these as corrections, with reversed sign, to the results for 54 years found in § 11, these become

$$\text{I.} \quad -\ 3 \sin\theta - \ 5 \cos\theta = \ 6 \cos(\theta - 211^\circ).$$
$$\text{II.} \quad -\ 3 \sin\theta - 10 \cos\theta = 11 \cos(\theta - 197).$$
$$\text{III.} \quad +10 \sin\theta - \ 6 \cos\theta = 12 \cos(\theta - 121).$$

The phase consistently decreases, though the amount of decrease is uncertain from the scanty material. If we take the first and third period it is 45°: but the coefficients of the first period are small, and a slight alteration would make them agree with the larger change indicated by II. and III. If we adopt 60° provisionally the correct period would be

$$54(1 - 60/360) = 45 \text{ years},$$

which differs considerably from 3 times $11\frac{2}{3}$ years, though it might be identified with 3 times 13·5 years. It appears on trial that a slight change in the elements of the long-period ($75 \pm$ years) term alters this other term sensibly: and if the two terms can be clearly separated and determined, it must be by a more elaborate investigation than can be undertaken at the moment.

Meanwhile, the facts above reviewed are sufficient for two purposes.

14. Firstly, they suffice to explain certain conflicting statements made about these long periods. Wolf alleged the existence of a 54-year period from the earlier observations; while Dr. W. J. S. Lockyer, on reviewing the later observations 1833–1900, writes (*Proc. R.S.*, lxviii. p. 300):—

"There is no indication of the 55-year period as suggested by Dr. Wolf.

"The climate variations indicated by Professor Brückner are generally in accordance with the 35-year period."

We see from § 11 that from the first 2×54 years (1749 to 1857), taking the observations as they stand, we get two fairly accordant terms of about 54 years, viz. $20 \cos(\theta - 184^\circ)$ and $26 \cos(\theta - 234^\circ)$: and from § 12 we see that the 72-year term is here helping the 54-year term. But in the next 54-year cycle the 72-year influence is reversed, and from the observations as they stand we get $12 \cos(\theta - 42^\circ)$, of opposite phase to the previous ones. Hence, in a combination of this last period (1858 to 1910 or a large portion of it), with part of the previous periods such as Dr. Lockyer takes (1833–1900), the 54-year term will practically disappear. On the other hand, if we first remove the 72-year term the shorter term appears consistently, though with a smaller coefficient than Wolf assigned, and with a period which is neither 35 years nor 55 years, but about $45 \pm$.

15. Secondly, the facts reviewed in §§ 10–13 suggest a rearrangement of the comparison between the Sun and S Persei. The similarity of the numbers 840, 1120, 3360 to 8·17, 11·13, and 33·38 is striking, but it depends partly on a fortuitous choice of units. Our examination has brought out the following additional facts:—

(*a*) The 33·38-year period for sunspots, though it is represented by its submultiples, does not itself occur with a sensible coefficient. There is, however, apparently a period of about 45 years, and another more conspicuous of nearly double this length.

(*b*) We find nothing in S Persei corresponding to the 13·5 year in sunspots.

(*c*) But we find a period of about 665 days in S Persei with no sensible 6·75 year period in sunspots.

16. The question, therefore, arises whether the two triplets do not correspond: *i.e.* sunspots 8·17, 11·12, 13·5 with S Persei 665, 840, 1120. The last two periods are, however, only adopted values: if we take the corrections to them found directly from the observations, they should be rewritten as 845 and 1073 days. The 665, though originally adopted for convenience (as $19 \times 70/2$), turns out to be sensibly correct. The ratios to the sunspot periods, which we take as precisely $\frac{1}{4}$, $\frac{1}{3}$, and $\frac{2}{5}$ of 33·375 years, or 12186 days:

$$665 \times 4/12186 = 2660/12186 = \cdot 218$$
$$845 \times 3/12186 = 2535/12186 = \cdot 208$$
$$1073 \times 5/24362 = 2687/12186 = \cdot 220.$$

We may take the mean ratio as ·215 = 1/4·65. If we prefer to express the sunspot period in years, the ratio is 0·0128 = 1/78·5.

17. Now if this be the relationship, how are the other periods related? For instance, in § 7 we have found a long period of 3669 days in S Persei. This corresponds to 46·7 years in the Sun, which is pretty close to the 45 years found in § 13. But this 45-year period was accompanied in the Sun by a 75-year, corresponding to 5890 days in S Persei. This is approximately 84 terms of 70 days each, or nearly the whole extent of our observations. We cannot therefore adequately confirm the existence of such a period, but, taking the first 84 terms and analysing them, we get the result

$$0{\cdot}22 \cos (\theta - 300^\circ) \qquad \text{max. at J.D. } 6572.$$

Or, taking the last 84 terms instead as the best rough check at present available, we get

$$0{\cdot}30 \cos (\theta - 268^\circ) \qquad \text{max. at J.D. } 6848.$$

Turning now to the shorter periods, let us look for the new analogy to the 4·77-year period under the changed conditions: its period should now be $\frac{3}{7}$ of 845 days (instead of $\frac{3}{7}$ of 1120 as previously considered in § 8)—that is, 363 days. Since $5 \times 70 = 350$ days, let us adopt this for convenience and note the change of phase.

We can reduce the accidental errors by adding five consecutive series of 350 days together: and we get three whole sets and four over, thus:

Sums of Five Terms of Table I.

First five	− 2	+ 1	+ 2	+ 3	+ 6
Second five	− 14	− 7	+ 7	+ 6	− 7
Third five	+ 12	+ 12	+ 19	+ 28	+ 28
Last four	+ 17	+ 14	+ 8	+ 1	+ 16

Analysing these we get

$$-{\cdot}04 \sin\theta - {\cdot}03 \cos\theta = {\cdot}05 \cos(\theta - 233^\circ) \qquad 233^\circ - 0^\circ = 233^\circ$$
$$+{\cdot}01 \sin\theta - {\cdot}19 \cos\theta = {\cdot}19 \cos(\theta - 177^\circ) \qquad 177 - 67 = 110$$
$$-{\cdot}16 \sin\theta - {\cdot}09 \cos\theta = {\cdot}18 \cos(\theta - 241^\circ) \qquad 241 - 134 = 107$$
$$+{\cdot}02 \sin\theta + {\cdot}13 \cos\theta = {\cdot}13 \cos(\theta - 9^\circ) \qquad 369 - 195 = 174$$

18. We have adopted 350 days, and the theoretical period is 363. This means an increase of phase of 13°·4 per period, or 67° in 5 periods and 61° in 4½ for use with the last set. With this assumption of change the two largest coefficients are brought into close accord. The others are somewhat discordant: but if we assume that the theoretical phases are as in the column q_c,

q_c.	q_o.	$Q = q_o - q_c$.	p.	$p \sin Q$.	$p \cos Q$.	Diff.
130°	233°	+103°	·05	+·05	−·01	−·12
197	177	− 20	·19	−·06	+·18	+·07
264	241	− 23	·18	−·07	+·17	+·06
325	369	+ 44	·13	+·07	+·09	−·02
				±·06	+·11	±·07

then the column $p \cos Q$ gives the component of the periodicity which agrees with the adopted phase. The mean value is $+0{\cdot}11 = p_1$, say, which we may adopt as the coefficient of the inequality. The deviations from the mean in $p \cos Q$, and the whole of $p \sin Q$, represent the unexplained part of the observed terms.

19. Now, these quantities are all so small that it may seem unjustifiable to pay further attention to them; and if this instance stood alone I should not venture to do so even for the sake of illustration. But some years of experience in dealing with such matters in other cases have gradually matured the conviction that it is well worth while to follow the matter further. Let us subtract from the observed residuals (s_1 and c_1 below) their theoretical values $p_1 \sin q_c$ and $p_1 \cos q_c$. The differences s_2 and c_2 may now be examined for a neighbouring periodicity, by a process similar to that already employed. We find q_2 from the equation

$$\tan q_2 = s_2/c_2,$$

and it is seen to increase by about 140°. (An automatic process has been devised for assigning the precise value, but need not be given here.) Deducing the new coefficient p_2 in the same way as p_1, we find it to be 0·10.

q_c.	$p_1 \sin q_c$.	$p_1 \cos q_c$.	s_1.	c_1.	s_2.	c_2.	q_2	q_c.	$\cdot 10 \sin q_c$.	$\cdot 10 \cos q_c$.
130°	+·08	−·10	−·04	−·03	−·12	+·07	300°	330	−·05	+·09
197	−·03	−·11	+·01	−·19	+·04	−·08	153	110	+·09	−·03
264	−·11	−·01	−·16	−·09	−·05	−·08	212	250	−·00	−·03
325	−·06	+·09	+·02	+·13	+·08	+·04	64	16	+·03	+·10

The period of the term represented by q_c is

$$350(1 \times 140/5 + 360) = 376 \text{ days},$$

the analogy for which in sunspots is 4·81 years, whereas that of the former period is 4·77. The evidence thus points to a "double line" at this point, and reference to Dr. Schuster's paper shows that there is an uncertainty about the sunspot periods of much the same kind. If from the above table we form the residuals

$$s_3 = s_2 - \cdot 10 \sin q_c \quad \text{and} \quad \cos c_3 = c_2 - \cdot 10 \cos q_c,$$

we find evidence of a third period still shorter than 4·77: but until more convincing cases of the real existence of such neighbouring periodicities have been published, the matter is better left at this stage.

20. We may now summarize the comparison as in the following table. The intensities in the last column are the squares of the coefficients of the terms as found from observation, and it will be seen that there is a fair accordance even in the intensities.

Comparison of Periodicities of Sunspots and S Persei.

Ratio to Main Period.	Period. Sunspots Years.	Period. S Persei Days. C.	Period. S Persei Days. O.	Intensities. Sunspots 10^3 omitted.	Intensities. S Persei $10-2$ omitted.
7?	78	6040	6000?	900	6
4?	44·5	3452	3669	300	6
$\frac{6}{5}$	13·35	1047	1073	696	6
1	11·125	863	845	4230	36
$\frac{3}{4}$	8·344	647	665	1000	7
$\frac{2}{7}$?	4·768 (double)	370	376 363	167	1 1

Baxendell's Observations of Variable Stars. Edited by H. H. Turner. No. 1, R Arietis.

The circumstances under which the observations of Pogson and Baxendell were put into my hands are mentioned in *Mon. Not.*, lxvii., pp. 119 and 316, and the advantages are there indicated of a policy of publishing the results for individual stars separately. Since that time Pogson's observations have been edited by Mr. C. L. Brook (*Mem. R.A.S.*, lviii.). A great part of Baxendell's observations have been dealt with by Miss Blagg and myself, especially the observations of the following twenty-three long-period variables:—

R Arietis	U Cygni	R Herculis	R Sagittæ
R Bootis	R Delphini	S Herculis	R Serpentis
R Cancri	S Delphini	T Herculis	T Serpentis
R Coronæ	T Delphini	R Leonis	R Ursæ Majoris
S Coronæ	S Geminorum	S Orionis	S Ursæ Majoris
T Tauri		R Persei	S (2) Vulpeculæ

There would be obvious advantages in presenting this material all together, but the desire to secure them has merely led to delay, since the final revision of such a large piece of work at once requires an undisturbed interval which is not easily found. On the other hand, it is moderately easy to find time to put into shape one star, or even two, and to revise the proof while the special points raised by it (for each star presents its own problems) are fresh in the mind. A beginning is therefore made in the present paper with R Arietis, and the others will follow in alphabetical order as opportunity offers. I may perhaps be allowed to express my regret that Miss Blagg does not wish her name to appear as joint editor. The great part of the work is due to her.

No. 1, R Arietis (782 *Chandler*) $2^h\ 10^m\ 25^s + 24^\circ\ 35'{\cdot}5$ (1900·0).

1. *The Comparison Stars.*—Baxendell made his own rough observing charts, frequently changing them; this makes the work

of editing his observations more than usually laborious. But there is seldom any real doubt as to the identifications, and when there is, the omission of a single doubtful observation is the plan which experience recommends, rather than the perpetuation of the troubles arising from it. The comparison stars for R Arietis have been identified as in Table I.

TABLE I.

A.S.V. No.	A.S.V. Mag.	H.A. Mag.	Baxendell's Diagrams. 1859 Nov. 16.	1860 Nov. 18.	1861 Oct. 9.	1863 Nov. 2.	1864 Dec. 21.	1866 Oct. 10.	Adopted Mag.
1	(6·0)	...	...	21	...	21	21	21	57
...	...	...	...	...	...	*a*	*a*	...	88
4	8·9	8·71	..	...	...	*b*	*b*	...	89
7	9·4	...	*a*	*a*	...	*c*	*c*	*a*	99
9	9·6	10·05	...	*c*	...	*d*	*d*	*b*	101
10	9·7	...	...	*f*	*h*	...	...	...	104
12	9·9	...	*d*	*d*	*g*	...	...	...	107
13	10·0	...	...	...	...	*e*	*e*	...	109
14	10·0	11·15	...	*e*	...	*f*		..	110
18	10·7	12·87	...	...	...	*x*	*x*	...	125
19	10·8	...	...	...	...	*y*	...	...	126
20	10·9	12·32	...	...	...	*z*	*z*	...	127
26	11·3	13·26	...	...	...	ϕ	ϕ	...	135

In the first two columns are given the number and magnitude of the star in Hagen's *Atlas Stellarum Variabilium*; in the next, the magnitudes of such of these as appear in *Harv. Ann.*, xxxvii. II. 153: then follow the designations in Baxendell's various pencil diagrams made on the dates given at the heads of the columns; and finally, an *adopted magnitude* (decimal point omitted) which has been used as the uniform designation of the star in the observations, according to the convenient practice of Pogson (see *Mem. R.A.S.*, lviii. p. 10, etc.). These adopted magnitudes have been chosen to fit the Harvard scale approximately, and yet to follow Baxendell's peculiarities.

Experience shows that every observer has his own values for the comparison stars, which in individual cases may differ considerably from a regular photometric scale.* To test such peculiarities in the case of Baxendell, a procedure was adopted similar to that followed in discussing the Rousdon observations (*Mem. R.A.S.*, lv.) viz., whenever the variable was compared with more than one comparison star, the recorded differences between the comparison stars were noted and collected. These differences are exhibited in Table II. Cases where the total number of available comparisons does not exceed *four* have been omitted, as also some discordances where the identification is doubtful.

* See, for instance, *Mem. R.A.S.*, lv. p. xxii *et seq.*

TABLE II.

Baxendell's Differences between his Comparison Stars. The unit is 0·1 mag. throughout. The subscript figures give the number of observations.

Years.	89–88.	99–88.	99–89	101–88.	101–89.	101–99.	110–107.	125–110.	126–125.	127–125.
1858	...	10_1	...	...	...	3_9	0_4	..	...	...
1859	...	9_3	...	12_1	...	3_6	3_1	...	...	...
1860	...	10_{10}	...	...	...	2_1	...	...	...	...
1861	2_2	12_5	10_2	...	...	4_3	...	...	0_3	...
1862	2_{11}	11_5	9_5	...	...	2_3	...	...	...	...
1863	4_9	14_5	10_8	10_1	10_4	0_8	...	15_1	...	6_1
1864	3_8	13_3	11_3	...	...	2_3	...	...	...	..
1865	1_9	...	10_2	...	...	...	...	17_2	...	2_1
1866	1_{10}	14_4	12_6	...	...	0_1	...	...	...	...
1867	1_6	12_4	10_7	...	11_3	0_3	...	...	...	...
1868–69	1_5	13_1	11_6	...	...	2_4	...	...	..	...
1877–78	1_9	...	...	...	...	...	...	...	2_1	...
1879–80	0_{12}	11_1	10_4	8_2	12_1	2_3	...	...	2_1	12_3
1881–83	1_4	..	13_3	...	12_3	-1_2	...	22_1	...	...
1884–85	1_5	...	15_4	...	16_4	0_7	...	...	2_1	2_4
1886–87	0_{11}	...	15_1	8_1	6_1	...	...	15_1	-3_1	...
Means	1·3	11·6	11·0	9·2	11·9	1·6	0·6	17·2	0·4	5·8
No. Obs.	101	42	51	5	16	53	5	5	7	9

In Table III. are given the observations. The telescopes used may be briefly designated as follows:—

A = 5-in. equatorial refractor, 70-in. focus, by Dancer.
R (13) = 13-in. reflector, made by Baxendell.
R (12) = 12-in. reflector, belonging to Mr. Williamson.
30 (*a*) = 30-in. achromatic.
22 (*a*) = 22-in. achromatic, $2\frac{3}{4}$-in. aperture, by Dancer.
T = Small Tully telescope.
C = A comet-seeker of $2\frac{1}{4}$-in. aperture.
E = 6-in. equatorial, $87\frac{1}{2}$-in. focus, used at Southport.

Fuller descriptions will be found in *M.N.*, lxvii. p. 316.
The dates of use were as follows:—

A 68:—1858 Nov. 11 to 1869 Dec. 21, with the following exceptions—

22 (*a*) 39 on 1859 Sept. 4 and Oct. 21.
R (13) 196 on 1859, Nov. 30.
R (13) 81 on 1861, Oct. 9 and 28; 1865 Nov. 26.
C 39 on 1861 Jan. 1; 1862 July 24 and Sept. 23; 1865 Nov. 13.

E 48 from 1877 Nov. 24 to end; except on 1878 Nov. 25, when A 56 was used.

Baxendell occasionally (especially in the early years) recorded the time of observation; but as it can usually not be inferred, it has been omitted from the record. It seems doubtful whether anything of value is added by it in the case of long-period variation (see *Mem. R.A.S*, lv. p. xviii). Baxendell's steps have, in column 3, been converted into tenths of a magnitude by means of the following scale, deduced from an extended comparison of his intervals with Harvard magnitudes:

Bax.	½	1	1½	2	2½	3 to 4	4½ or 5	5½ to 6½	7 & 7½	8 to 9
Tenths	0	1	1	2	2	3	4	5	6	7
Bax.	9½ to 10½		11 to 12		12½ to 13½	14 to 15½		16 to 17½	18 to 19	20
Tenths	8		9		10	11		12	13	14

The conversion is accurately represented by the formula

$$t = 0{\cdot}9158 - 0{\cdot}0115s^2$$

where s is the value in steps, and t in tenths of magnitude.

TABLE III.

Baxendell's Observations of R Arietis.

Date.	Julian 240+.	Comparisons.	Deduced Mag.	Date.	Julian. 240+.	Comparisons.	Deduced Mag.
1858				1859			
Nov. 11	(9995)	99 + 3, 101 + 2, 107 − 2	103	Aug. 10	0267	99 − 5, 101 − 7	94
				19	0276	99 − 2	97
22	0006	99 − 1, 101 − 4	97	22	0279	99 + 2, 101 − 1	100
23	0007	99 − 1, 101 − 4	97	Sept. 4	0292	< 126	
24	0008	99 − 1	98	Oct. 21	0339	< 107	
26	0010	99 + 0, 101 − 4	98	Nov. 16	0365	107 + 6, 110 + 3	113
Dec. 2	0016	99 − 1	98	24	0373	110 − 0	110
2	0016	99 − 1	98	30	0379	110 − 2	108
4	0018	99 − 2, 101 − 6	96	Dec. 14	0393	99 − 1, 101 − 3	98
5	0019	99 − 2, 101 − 6	96	21	0400	99 − 6, 88 + 2	92
20	0034	99 − 8, 88 + 0	90	1860			
22	0036	99 − 8	91	Jan. 6	0416	99 − 8, 88 − 1	89
29	0043	99 − 7, 101 − 9	92	11	0421	99 − 8, 88 − 1	89
1859				14	0424	99 − 7, 88 + 0	90
Jan. 12	0057	99 − 7	92	17	0427	99 − 7, 88 + 0	90
19	0064	99 − 8, 101 − 9	92	31	0441	99 − 8, 88 + 2	90
Feb. 14	0090	99 + 3, 101 + 1	102	Feb. 6	0447	99 − 6, 88 + 3	92
July 12	0238	99 − 9	90	9	0450	99 − 8, 88 + 2	90
24	0250	99 − 7, 88 + 0	90	14	0455	99 − 5, 88 + 5	94
29	0255	99 − 6, 101 − 8, 88 + 2	92	28	0469	99 + 3, 101 + 1	102
				July 12	0604	57 + 9, 99 − 14	76

TABLE III.—*Baxendell's Observations of R Arietis*—continued.

Date.	Julian 240+.	Comparisons.	Deduced Mag.
1860			
July 29	0621	99 − 10, 88 − 3	87
Nov. 18	0733	110 + 5, 104 + 6	112
Dec. 18	0763	99 + 1, 101 − 9	96
28	0773	99 − 12, 88 − 3	86
1861			
Jan. 1	0777	88 − 2	86
4	0780	57 + 14, 99 − 11, 88 − 3	81
6	0782	88 − 3, 99 − 12	86
12	0788	89 − 4, 99 − 10	87
15	0791	88 − 3, 89 − 3, 99 − 11	86
28	0804	88 + 0, 89 − 3, 99 − 9	88
Feb. 10	0817	99 − 6, 88 + 4	92
24	0831	99 + 2	101
Mar. 10	0845	107 + 5, 104 + 4, 110 + 0	110
Oct. 9	1058	125 + 1	126
28	1077	125 + 5	130
Nov. 2	1082	125 + 7	132
11	1091	126 + 3	129
27	1107	109 − 3	106
Dec. 3	1113	101 + 7, 110 − 4	107
21	1131	99 + 2, 101 − 3	100
25	1135	99 + 0, 101 − 3	98
28	1138	99 − 1, 101 − 4	98
1862			
Jan. 5	1146	99 − 6, 88 − 2, 89 − 4	88
18	1159	88 − 3, 89 − 4, 99 − 11	86
22	1163	88 − 4, 89 − 5, 99 − 12	85
26	1167	88 − 2, 89 − 4, 99 − 12	86
Feb. 3	1175	88 − 2, 89 − 4	86
8	1180	88 − 3, 89 − 4	85
1862			
Feb. 10	1182	88 − 3, 89 − 4	85
16	1188	88 − 1, 89 − 3	86
20	1192	88 + 2, 89 + 0	90
25	1197	88 + 6, 89 + 3, 99 − 4	94
Mar. 15	1215	99 + 3, 101 + 1	102
July 24	1346	88 − 2, 89 − 2	86
Sept. 23	1407	99 + 3, 101 − 1	101
Oct. 29	1443	Invisible.	
Nov. 10	1455	,,	
16	1461	110 + 9, 126 − 2	122
24	1469	110 + 5	115
Dec. 26	1501	99 + 1, 101 + 2	102
30	1505	>99, >101	
1863			
Jan. 2	1508	99 − 2, 101 − 3	98
4	1510	89 + 4, 101 − 4, 99 − 4	95
7	1513	89 + 3, 101 − 6, 99 − 7	93
10	1516	89 + 3, 101 − 6, 99 − 7	93
23	1529	88 + 0, 89 − 2, 99 − 7, 101 − 8	90
29	1535	88 + 0, 89 − 3,	87
Feb. 3	1540	88 − 1, 89 − 4, 99 − 12	86
12	1549	88 + 2, 89 − 3	88
15	1552	88 + 3, 89 − 2, 99 − 8	90
28	1565	88 + 2, 89 − 3	88
Mar. 3	1568	88 + 3, 99 − 8, 89 + 1	91
8	1573	88 + 8, 89 + 4, 99 − 6	94
22	1587	99 + 1, 101 + 2	102
July 3	1690	88 + 1, 89 + 2	90
Oct. 9	1788	101 + 0	101

TABLE III.—*Baxendell's Observations of R Arietis*—continued.

Date.	Julian 240+.	Comparisons.	Deduced Mag.
1863			
Nov. 2	1812	127 + 0	127
6	1816	? glimpsed	
11	1821	<130	
28	1838	110 + 6	116
29	1839	110 + 6, 125 − 7	117
Dec. 5	1845	110 + 0	110
17	1857	101 + 4, 110 − 5	105
27	1867	99 + 3, 101 + 0	102
1864			
Jan. 1	1872	101 + 1	102
4	1875	99 + 3, 109 − 7, 101 + 1	102
28	1899	88 + 1, 89 − 2	88
Feb. 5	1907	88 + 1, 89 − 1	88
8	1910	88 + 2, 89 + 1, 99 − 9	90
17	1919	88 + 1, 89 − 2	88
July 16	2069	88 + 3, 89 + 2	91
19	2072	88 + 2, 89 + 1, 99 − 9	90
26	2079	88 + 1, 89 − 1	88
Aug. 23	2107	88 + 1, 89 − 2, 99 − 7	89
Dec. 21	2227	99 + 2, 101 + 2	102
30	2236	99 + 2, 101 − 1	100
1865			
Jan. 4	2241	89 + 2, 99 − 6	92
6	2243	89 + 3, 99 − 6	92
20	2257	88 − 3, 89 − 3	86
Feb. 8	2276	88 − 5, 89 − 6	83
14	2282	88 − 3, 89 − 3	86
Mar. 3	2299	88 − 2, 89 − 4	86
9	2305	88 − 2, 89 − 2	86
Aug. 3	2452	88 + 1, 89 − 1	88
Sept. 27	2507	88 + 1, 89 − 1	88
Nov. 13	2554	Not seen.	
21	2562	127 + 2, 135 − 4	130
24	2565	125 + 6, 127 + 4	131
1865			
Nov. 26	2567	125 + 6	131
Dec. 14	2585	125 + 1	126
22	2593	110 + 9, 125 − 8	118
23	2594	110 + 4, 125 − 6	116
31	2602	110 − 3	107
1866			
Jan. 5	2607	101 + 6, 110 − 6	106
15	2617	99 − 2	97
20	2622	89 + 7, 99 − 3, 88 + 9	96
22	2624	89 + 4, 99 − 3	94
23	2625	89 + 3, 99 − 4	94
29	2631	88 + 0, 89 − 1, 99 − 11	88
Feb. 2	2635	88 − 1, 89 − 1, 99 − 11	88
4	2637	88 + 0, 89 − 1	88
12	2645	88 − 2, 89 − 1	87
17	2650	88 − 1, 89 − 2	87
25	2658	88 − 1, 89 − 1	88
Mar. 13	2674	88 − 1, 89 − 2	87
July 21	2804	88 + 2	90
Aug. 31	2845	88 + 1, 89 − 1, 99 − 9	89
Oct. 6	2881	99 + 0	99
10	2885	99 + 2, 101 + 0	101
Nov. 25	2931	Occasionally glimpsed.	
1867			
Jan. 11	2978	101 + 3, 99 + 1	102
21	2988	89 + 6, 99 − 3, 101 − 3	96
28	2995	89 + 2, 99 − 6, 101 − 7	93
Feb. 2	3000	89 + 2, 99 − 6	92
20	3018	99 − 10, 88 − 3, 89 − 2	87
28	3026	88 − 2, 89 − 3, 99 − 10	87

TABLE III.—*Baxendell's Observations of R Arietis*—continued.

Date.	Julian 240+.	Comparisons.	Deduced Mag.
1867			
Mar. 16	3042	88 + 2, 89 + 1	90
20	3046	88 − 1, 89 − 2, 99 − 11	87
26	3052	88 + 0, 89 − 1, 99 − 9	89
Aug. 1	3180	89 + 7, 101 − 3	97
21	3200	88 + 0, 89 − 2	88
1868			
Jan. 8	3340	99 + 6, 101 + 4	105
26	3358	101 − 1, 99 − 2	98
Feb. 3	3366	89 + 4, 99 − 5	94
8	3371	89 + 4, 99 − 6	93
11	3374	89 + 4, 99 − 5	94
15	3378	88+48, 89 + 3, 99 − 7	92
19	3382	89 + 0, 99 − 8	90
Mar. 5	3397	88 − 4, 89 − 4	84
July 23	3537	88 + 0, 89 − 2	88
25	3539	88 − 1	87
Sept. 5	3581	88 − 5, 89 − 6	83
Oct. 17	3623	88 − 1	87
1869			
Jan. 24	3722	99 + 1, 101 + 0	100
Feb. 5	3734	89 + 7, 99 − 3	96
Oct. 26	3997	99 + 2, 101 − 2	100
Dec. 21	4053	< 126	
1877			
Nov. 24	6948	88 − 1, 89 − 2	88
1878			
Jan. 31	7016	109 − 1	108
Aug. 10	7207	110 + 4	114
25	7222	125 + 2, 126 + 0	126
29	7226	125 + 3	128
Sept. 5	7233	125 + 4, 126 + 3	129
Oct. 13	7271	101 + 0	101
17	7275	99 + 2, 101 − 7	98
27	7285	99 − 3	96
Nov. 17	7306	88 − 3, 89 − 5	84
1878			
Nov. 19	7308	88 − 4, 89 − 6	84
25	7314	89 − 6, 88 − 6	82
28	7317	88 − 5, 89 − 6	83
Dec. 5	7324	88 − 4, 89 − 4	84
8	7327	88 − 4, 89 − 6	84
22	7341	88 − 2, 89 − 3	86
30	7349	88 − 2, 89 − 3	86
1879			
Jan. 13	7363	88 + 4, 101 + 0	96
22	7372	101 + 3	104
25	7375	101 + 3	104
Aug. 17	7579	110 + 1	111
23	7585	110 + 4	114
28	7590	110 + 8	118
Sept. 13	7606	127 − 2, 125 + 8	129
19	7612	125+10, 127 + 1	132
25	7618	125 + 9, 127 − 2	130
Oct. 14	7637	125 − 7	118
20	7643	110 + 0	110
Nov. 1	7655	101 + 1	102
10	7664	101 − 1	100
13	7667	89 + 4, 99 − 3	94
21	7675	88 − 1, 89 − 2	87
29	7683	88 − 2, 89 − 4	86
Dec. 3	7687	88 − 3, 89 − 3	86
6	7690	88 − 2, 89 − 3	86
22	7706	88 − 6, 89 − 6	82
1880			
Jan. 2	7717	89 − 3, 88 − 3	86
11	7726	88 − 2, 89 − 2	86
21	7736	88 + 2, 89 + 2	90
28	7743	89 + 6, 99 − 3, 88+6, 101 − 4	95
Feb. 1	7747	99 − 1, 101 − 1	99
5	7751	101 + 3, 109 − 4	104
Mar. 8	7783	about 125 + 0	125
July 20	7917	89 + 5, 99 − 5	94
30	7927	99 − 2	97

TABLE III. *Baxendell's Observations of R Arietis*—continued.

Date.	Julian 240+.	Comparisons.	Deduced Mag.
1880			
Aug. 9	7937	99 + 2, 101 − 2	100
12	7940	101 + 3	104
28	7956	110 − 1	109
Sept. 3	7962	110 + 3	113
27	7986	125 + 4	129
Oct. 2	7991	125 + 3, 126 + 0	127
9	7998	125 − 2	123
29	8018	109 − 2	107
Nov. 19	8039	99 − 3, 101 − 3	97
26	8046	99 − 2	97
Dec. 4	8054	89 + 3, 99 − 7	92
20	8070	89 − 3	86
21	8071	89 − 4, 88 − 5	84
25	8075	88 − 3, 89 − 3	86
30	8080	89 − 2, 88 − 3	86
1881			
Feb. 6	8118	89 + 8, 99 − 3, 101 − 1	98
20	8132	101 + 9, 110 − 2, 109 + 0	109
July 20	8282	89 + 0	89
Aug. 1	8294	88 + 3, 89 + 2	91
24	8317	89 + 8, 101 − 2	98
Sept. 14	8338	110 + 4	114
Oct. 2	8356	125 + 6	131
15	8369	125 − 2	123
29	8383	110 + 4, 125 12	114
Nov. 14	8399	101 + 2	103
17	8402	101 − 2	99
22	8407	101 − 2	99
28	8413	89 + 7, 101 − 4, 99 − 4	96
Dec. 19	8434	88 − 2, 89 − 3	86
27	8442	89 − 3, 88 − 3	86
1882			
Aug. 19	8677	89 + 3, 88 + 4	92
Sept. 9	8698	101 + 6, 110 − 4	106
1883			
Aug. 25	9048	89 + 7, 99 − 3	96
Oct. 28	9112	125 + 7	132
1884			
Feb. 2	9209	89 + 3, 99 − 6	92
10	9217	89 + 3, 101 − 9	92
11	9218	89 + 4, 99 − 6, 101 − 7	93
14	9221	89 + 7, 99 − 9, 101 − 8	93
24	9231	89 + 10, 99 − 3, 101 − 1	98
Mar. 3	9239	99 − 1, 101 − 2	98
5	9241	99 + 1, 101 + 2	102
July 27	9385	88 − 2, 89 − 3	86
Aug. 14	9403	88 − 2, 89 − 3	86
18	9407	88 − 1, 89 2	87
23	9412	88 + 0, 89 − 1	88
Sept. 11	9431	99 + 2, 101 + 0	101
20	9440	101 + 10, 110 − 6	108
Oct. 9	9459	125 + 8	133
Nov. 17	9498	126 + 6	132
Dec. 4	9515	110 + 7	117
14	9525	110 + 1	111
15	9526	110 + 0	110
1885			
Jan. 6	9548	101 + 6, 110 − 1	108
15	9557	101 − 2, 99 2	98
Feb. 3	9576	89 + 4	93
22	9595	101 − 3	98
Aug. 14	9768	88 − 4, 89 − 4	84
19	9773	88 − 1, 89 − 1	88
Sept. 8	9793	101 − 2	99
Oct. 29	9844	126 + 4, 127 + 0	128
1886			
Jan. 6	9913	88 + 1, 89 + 0, 101 − 6	91
11	9918	88 − 1, 89 2,	87

TABLE III.—*Baxendell's Observations of R Arietis*—continued.

Date.	Julian 240+.	Comparisons.	Deduced Mag.	Date.	Julian 240+.	Comparisons.	Deduced Mag.
1886				1886			
Feb. 1	9939	88 − 5, 89 − 6	83	Nov. 16	0227	127 + 2, 135 − 4	130
14	9952	88 − 5, 89 − 5	84	30	0241	126 + 5	131
26	9964	89 − 3, 88 − 3	86	Dec. 4	0245	126 + 6	132
Mar. 8	9974	88 + 4, 89 + 5	93	29	0270	101 − 1	100
Sept. 18	241 + 0168	89 + 4, 99 − 8	92	1887			
				Jan. 12	0284	89 + 3, 88 + 3	92
Oct. 23	0203	110 + 2	112	26	0298	88 + 3, 89 + 2	91
Nov. 2	0213	110 + 8, 125 − 4, 126 − 1	121	29	0301	88 − 2, 89 − 3	86
				Feb. 18	0321	89 − 2, 88 − 2	86
7	0218	125 + 0	125	Mar. 3	0334	89 − 4, 88 − 3	85

Light Curve and Analysis of Results.

To express these results in more compendious form the following procedure was adopted. Assuming an approximate period of 186 days, this was divided into twelve portions of alternately 15 days and 16 days: and the whole series of observations was divided accordingly, taking the means of all the observations in each portion, irrespective of their position in the group. From inspection of these means it was clear that the period was nearer 187 days than 186, as will be seen from the means of large groups:—

Group.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
A	103	94	88	88	90	96	103	(101)	126	131	121	110
B	96	94	88	87	87	91	101	...	...	130	126	107
C	118	104	97	88	86	86	89	96	104	113	127	129
D	132	124	105	90	96	87	87	95	98	108	124	129
E	98	94	88	87	89	95	103	101	126	130	122	108
F	124	111	100	89	88	87	88	95	102	112	126	129

The groups are much as in Table IV., viz.: A = II. to XI., B = XII. to XXI., C = XXXIX. to XLVIII., D = L. to LVII., and E = A + B, F = C + D.

When the whole series is divided into two, as in the last two lines, we see that there is a shift of phase of about two portions. The observations were accordingly rearranged in groups of 187 days in the same way and a mean light curve found from the whole material, giving means for the twelve portions as at the head of Table IV. The mean magnitudes naturally apply to the mean of the portion, so that the epoch for the first (98) is 2399998 + 187 E.

TABLE IV.

Comparison of the Observations with a Mean Light Curve.

Period.	Initial Date 240+.	Number and Mean Magnitude of Portion. 1. 98.	2. 92.	3. 88.	4. 87.	5. 89.	6. 95.	7. 104.	8. 113.	9. 127.	10. 129.	11. 123.	12. 105.
II.	(9990)	$+5_1$	$+5_8$	$+2_1$	$+4_2$	$+3_2$	...	-1_1	...	...	...	...	...
III.	0177	...	...	...	$+2_1$	$+1_1$	-1_2	-4_2	...	...	...	...	...
IV.	0364	$+13_2$	$+10_2$	$+3_1$	$+2_3$	$+2_1$	-3_4	-3_1	...	...	...	...	...
V.	0551	...	...	...	-2_1	-1_1	...	...	...	...	...	...	$+9_1$
VI.	0738	...	$+5_1$	-3_4	-1_2	0_1	$+1_1$	$+3_2$	...	...	...	...	...
VII.	0925	...	...	...	...	...	...	...	...	-1_1	$+1_1$	$+7_2$	$+3_1$
VIII.	1112	$+6_1$	$+7_3$	-1_1	-2_3	-3_4	-2_2	-2_1	...	...	...	...	...
IX.	1299	...	...	...	-1_1	...	...	...	-6_1	...	...	-3_1	$+1_1$
X.	1486	...	$+5_5$	$+3_1$	-1_2	$+1_2$	-2_3	-2_1	...	...	...	...	...
XI.	1673	...	-4_1	...	...	...	...	...	-11_1	...	-2_1	-5_2	$+1_2$
XII.	1860	$+5_2$	$+7_1$	0_1	$+2_3$	...	...	...	...	...	...	...	...
XIII.	2047	...	-1_2	-1_1	$+2_1$	...	...	...	...	...	...	...	-2_1
XIV.	2234	-3_3	-6_1	-5_1	-2_1	-2_2	...	...	...	...	...	...	...
XV.	2421	...	...	-1_1	...	...	-7_1	...	...	...	$+2_3$	$+3_1$	$+5_4$
XVI.	2608	$+1_2$	-2_5	-1_2	0_1	-1_1	...	...	...	...	...	...	...
XVII.	2795	-7_1	...	...	$+2_1$	...	$+3_2$	...	...	..	...	...	-1_1
XVIII.	2982	-2_2	-2_1	$+1_2$	$+3_1$	0_2	...	...	...	...	...	...	...
XIX.	3169	$+1_1$	...	-2_1	...	...	...	...	...	...	...	...	-8_1
XX.	3356	-2_2	-1_4	-3_1	...	...	...	...	...	...	...	...	-16_2
XXI.	3543	...	...	-5_1	...	...	-6_1	...	...	...	...	...	-4_1
XXII.	3730	-3_1	...	...	...	...	...	...	...	...	...	...	...
XXIII.	3917	...	...	...	...	...	$+8_1$	...	...	...	...	...	...
XXXIX.	6909	...	...	-1_1	...	...	...	$+1_1$	...	...	...	...	...
XL.	7096	...	...	...	...	...	...	..	$+5$	$1+3_3$	...	...	-8_2
XLI.	7283	-3_1	-7_2	-5_4	-1_1	-2_1	$+5_2$	$+5_1$	...	...	...	...	...
XLII.	7470	...	...	...	...	...	...	...	$+2_3$	$+1_1$	$+2_2$	-1_1	0_2
XLIII.	7657	0_2	-5_3	-3_1	-3_2	-2_1	0_3	$+4_1$	...	$+4_1$	...	...	...
XLIV.	7844	...	...	...	...	$+5_1$	$+3_1$	$+3_2$	-1_2	...	-1_3	...	-2_1
XLV.	8031	0_1	$+1_2$	-3_3	-1_1	...	$+1_1$	$+5_1$	...	...	...	...	...
XLVI.	8218	...	...	...	...	$+1_2$	...	-4_1	0_1	$+3_1$	-6_1	-8_1	-2_2
XLVII.	8405	-1_2	-4_1	-3_1	...	...	...	...	...	...	...	...	...
XLVIII.	8592	...	...	...	...	...	-3_1	0_1	...	...	...	...	...
L.	8966	...	...	...	...	...	$+2_1$	...	...	...	$+3_1$	...	...
LI.	9153	...	...	...	$+6_1$	$+5_3$	$+5_3$	...	...	...	...	...	...
LII.	9340	...	...	-1_1	...	-1_3	$+3_1$	$+5_1$	$+18_1$	...	...	$+5_1$	$+9_3$
LIII.	9527	...	$+12_2$	...	$+6_1$	$+11_1$	...	...	...	...	...	...	...

TABLE IV.—*Comparison of the Observations with a Mean Light Curve*—continued.

Period.	Initial Date 240+.	Number and Mean Magnitude of Portion. 1. 98.	2. 92.	3. 88.	4. 87.	5. 89.	6. 95.	7. 104.	8. 113.	9. 127.	10. 129.	11. 123.	12. 105.
LIV.	9714	...	...	...	-1_2	...	$+7_1$	...	...	$+4_1$	...	...	...
LV.	9901	-4_1	-7_1	-5_1	-4_1	$+1_2$	...	...	...	...	...	...	...
LVI.	(0088)	...	...	...	...	...	0_1	...	0_1	0_2	$+2_2$	$+5_1$	-3_1
LVII.	(0275)	-6_1	-3_2	...	-2_2	...	...	...	...	...	...	...	...
II.	+(9)	+8	+5	+1	0	0	−1	−2	−8	−1	−1	0	+3
XII.	+(9)	−1	−1	−2	+1	−1	−3	(0)	(−3)	(+1)	+2	+3	−4
XXXIX.	+(9)	−1	−4	−3	−2	+1	+1	+2	+2	+4	−2	−4	−3
L.	+(7)	−5	+1	−3	+1	+4	+3	+5	+9	+2	+2	+5	+3
	$p-f$	+13	+10	+5	−1	−8	−15	−18	−23	−16	+4	+24	+25

The procedure followed is similar to that described in *Mem. R.A.S.*, lv. p. lxv *et seq*, except that decimal points have been avoided as much as possible by expressing the quantities in units of 0·1 throughout, according to Pogson's convenient practice. Further, the means have often been taken to the nearest unit where perhaps another decimal might be justified. But it will be seen that the observations are few and far between, and probably the tenth of a magnitude is all we can reasonably be sure of.

At the foot of the columns are given the simple means for four large groups, the symbol II. + (9) denoting the II. and nine following periods. For three portions in the second group no observations are available, and bracketed means have been interpolated between the line above and the line below, as the best we can do.

From any pair of rows we can deduce the correction to the adopted period as shown by the average period in the interval between the rows. But a more complete process is to deduce the correction to epoch from each row singly as follows:—Let D denote the mean residual for any column, and $p-f$ the excess of the adopted mean magnitude (from the curve) for the preceding portion over that for the following, as shown at the foot of the column. Then the correction to the adopted epoch (which puts the maximum 52 days * after the initial date) is

$$\frac{N}{2\pi}\,\Sigma D(p-f)/\Sigma(p-f)^2$$

when Σ denotes summation for all twelve portions. Chandler's formula (Revision of Third Cat., *A.J.*, 553) is

$$2402849{\cdot}0 + 186{\cdot}55E + 7 \sin (5^\circ E + 235^\circ).$$

* Miss Blagg would read the curve so as to give less than this, say 50 days, which would bring the epoch nearer Chandler. But as the reading printed was made before the comparison with Chandler was known, it has been retained.

The results from Baxendell's observations may be compared with the formula as below :—

Group.	Mean E.	Chandler's Epoch. 240 +.	Baxendell's Epoch.	Bax. − Ch. (α)	Bax. − Ch. (β)
				d	d
II. +(9)	−10	0983·5 − 0·6	0925 + 52 + 4·9	−1·0	−1·5
XII. +(9)	0	2849·0 − 5·7	2795 + 52 + 0·5	+4·2	+2·2
XXXIX. +(9)	+27	7885·9 + 1·2	7844 + 52 − 4·2	+4·7	−1·3
L. +(7)	+37	9751·4 + 5·7	9714 + 52 − 2·8	+6·1	−1·4

The periodic term of Chandler's formula is shown separately; as also the correction to epoch deduced from Baxendell's observations. The differences (α) between Baxendell's observations and Chandler's formula indicate chiefly a correction to the mean period of Chandler (186·55 days) of about $0^d{\cdot}15$; making it 186·70. If we also alter the estimated Baxendell maximum 52 days into 50, as in the footnote, we get column (β), in which the differences are satisfactorily small. But it is well known that a maximum is an indefinite phase, and it is much better to analyse the results harmonically, when the epochs of the harmonics can be determined without any process of estimation by eye. In *Mon. Not.*, lxvii. pp. 336–341, this difficulty is discussed. Further consideration has led to the conclusion that it would be better to give up altogether the attempt to use the maximum as a zero point, and to choose instead the epoch of the first harmonic alone. But for convenience of comparison the results will first be expressed in the form adopted in the above two papers.

Taking the maximum, then, at 52 days from the adopted commencement, the mean curve (used in the reductions) can be expressed as follows in magnitudes:—

$$-2{\cdot}02\cos(\theta + 0^\circ{\cdot}4) + 0{\cdot}46\cos(2\theta + 4^\circ) - 0{\cdot}18\cos(3\theta - 27^\circ);$$

or, dividing by the whole range (4·18 magnitudes) and multiplying by 6, to compare with above papers,

$$-2{\cdot}90\cos(\theta + 0^\circ{\cdot}4) + 0{\cdot}66\cos(2\theta + 4^\circ) - 0{\cdot}26\cos(3\theta - 27^\circ).$$

The discussion of these figures is reserved until the whole Baxendell series is reduced: but it may be remarked that they fit in fairly well with the general formula connecting such light curves, except that the coefficient of the second harmonic is very large.

If we consider the light curve at different epochs, then analysing the results as they stand (*i.e.* to 0·1 mag. only) we get the following figures, expressed in magnitudes, and referred to our arbitrary zero :—

Mean curve	$2{\cdot}04\cos(\theta - 261^\circ) + 0{\cdot}44\cos 2(\theta - 262^\circ) + 0{\cdot}18\cos 3(\theta - 272^\circ)$
II. + (9)	$1{\cdot}90\cos(\theta - 274) + 0{\cdot}31\cos 2(\theta - 266) + 0{\cdot}33\cos 3(\theta - 263)$
XII. + (9)	$2{\cdot}13\cos(\theta - 262) + 0{\cdot}60\cos 2(\theta - 264) + 0{\cdot}16\cos 3(\theta - 276)$
XXXIX. + (9)	$2{\cdot}16\cos(\theta - 254) + 0{\cdot}39\cos 2(\theta - 256) + 0{\cdot}20\cos 3(\theta - 256)$
L. + (7)	$2{\cdot}28\cos(\theta - 254) + 0{\cdot}40\cos 2(\theta - 269) + 0{\cdot}13\cos 3(\theta - 291)$

Erratum in Vol. lxxiii., No. 1.

Page 58, line 17, *for* equator *read* ecliptic.